



SEGMENT F.1
PROJECT 12-777XF1

TECHNICAL CONSTRUCTION SPECIFICATIONS

ISSUED FOR BIDDING
NOT FOR CONSTRUCTION
(VOLUME 2 OF 5)

AUGUST 2026



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MEASUREMENT AND PAYMENT

PART 1 - GENERAL

1.01. DESCRIPTION

- A. Section includes: Procedures for measurement and payment of Work under this Contract including the use of owner authorized allowances.

1.02. BID ITEMS

- A. Item 1: Mobilization / Demobilization

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) Mobilization to the site and demobilization from the site and includes all preparatory costs for acquiring permits and approvals, temporary utilities, moving construction equipment, materials, and labor to the site, and all other costs incurred or labor and operations which must be performed prior to beginning the other bid items under the Contract.
- (2) Mobilization shall also include all preparatory efforts, including meetings, associated with developing and gaining approval of all Larimer County required Contractor plans/submittals for the Larimer County Development Construction Permit (DCP) as required by the City's 1041 Permit Conditions of Approval and as described in Specification Section 01 41 10 and 32 90 10.
- (3) Furnishing the bonds and meeting the insurance requirements that are required by the General Conditions. Bond cost shall be verified by the Owner based on the invoices from the insuring firm(s).
- (4) Demobilization including removal, disposal, service disconnects, and other work to completely remove equipment, and other work product from the construction work areas.

- b. Measurement for payment will be according to the Owner formula for mobilization as described in the General Conditions.

2. Payment:

- a. Lump Sum (LS).
- B. Item 2: Traffic Control
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - (1) Implementing a Traffic Control and Management Plan approved by Larimer County and the Owner.
 - (2) Establishing and maintaining traffic control devices according to the requirements set forth in the latest edition of the Quality Guidelines for Temporary Traffic Control Devices and Features published by the American Traffic Safety Services Association (ATSSA).
 - (3) Furnishing, installing, moving, maintaining and removing all temporary traffic elements including signs, variable messaging boards, concrete barriers, barricades, traffic cones, line markings, channelizing devices, warning lights, delineator, crushed rock surfacing, and any other equipment or personnel as required by the latest revision of the "Manual on Uniform Traffic Control Devices for Streets and Highways" and the requirements, including traffic control plans and travel notifications, of the entity having roadway jurisdiction.
 - b. Measurement for payment will be lump sum and shall be made on a Contract Price Earned (CPE) percentage basis excluding the amount paid for materials stored on site.
 - 2. Payment:
 - a. Lump Sum (LS) (paid on a monthly basis).
- C. Item 3: Implementation and Conformance with Stormwater Management Plan
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - (1) Implementing and maintaining a Contractor-developed Project Specific Stormwater Management, Erosion and Sediment Control, and BMP Plan (SWMP) Plan approved by Larimer County that conforms to the Drawings and Specifications and all applicable Federal, State, and Local permits.

- (2) Maintenance from start of construction through final acceptance.
- (3) Planning, designing, developing, applying for, and securing a stormwater discharge permit from the Colorado Department Public Health and Environment (CDPHE).
- (4) The development, implementation, inspection, reporting, and compliance efforts associated with the CDPHE construction stormwater permit and associated SWMP including all labor, materials, work, and all costs to develop, maintain, and restore the project site in compliance with the stormwater discharge permit and the SWMP.
- (5) Preparing and revising SWMP including drawings and reports, furnishing, installing, maintaining and removing best management practices (BMPs) including but not limited to: surface roughening, temporary seeding, mulching, check dams, silt fence, rock socks, inlet protection, concrete washout areas, stockpile management, construction fence, vehicle tracking control, stabilized staging areas, dewatering operations, erosion control blankets, and good housekeeping, and all other necessary materials, work, and equipment required to complete this item in accordance with the jurisdictional requirements relating to storm water and pollution controls.

b. Measurement for payment will be lump sum and shall be made on a Contract Price Earned (CPE) percentage basis. Measurement for payment will cover from the start of construction to final acceptance when the permit(s) is/are closed. Adequate funding will be reserved to ensure maintenance will occur through final completion and final payment will be made at permit closure.

c. All efforts associated with permanent seeding and final restoration shall be covered under Bid Item 48.

2. Payment:

a. Lump sum (LS).

D. Item 4: Trench Stabilization

1. Measurement:

a. Includes work for, but is not limited to, the following:

- (1) Excavation and removal of unsuitable material, and the furnishing and installation of trench stabilization material and fabric in the bottom of an unstable excavation or trench and all other necessary materials, work, and equipment required to complete this item in accordance with the Drawings and Specifications. This work will only take place after approval by the Construction Manager and the Owner.
 - (2) The use and payment for trench stabilization material shall be only where required to stabilize the trench and as approved by the Construction Manager and the Owner.
 - (3) Trench stabilization that is required due to unacceptable foundation conditions caused by the Contractor's failure to meet the specified dewatering requirements shall be at no additional cost to the Owner.
 - b. Measurement for payment will be unit price based on the estimated volume placed. Quantities will be determined from trench measurements of material placed as determined by the Construction Manager.
2. Payment:
- a. Unit price per Cubic Yard (CY).
- E. Item 5: CLSM Cutoff Walls
1. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - (1) Furnishing and installing controlled low-strength material (CLSM) trench cutoff walls including excavation, dewatering, backfilling, and materials for construction of cutoff walls including formwork, water, testing, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
 - (2) Cutoff walls installed at the Larimer County Canal crossings will be paid under Bid Items 23 and 25.
 - b. Measurement for payment will be unit price based on the actual number of CLSM trench cutoff walls installed. For bidding purposes, the bid form quantity includes the number of cutoff walls shown on the Drawings plus five (5) additional.
 2. Payment:

- a. Unit price per each (EA).

F. Item 6: Fiber Optic Conduit

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) Furnishing and installing three (3) HDPE fiber optic conduits with preinstalled pull tape including all, fittings, appurtenances, joint fusion, embedment material, marker tape, tracer wire, tracer wire test stations, detectable warning tape, locator balls, furnishing all mandrel testing equipment and conducting mandrel testing, removal of excess soil materials, connections, and stub-ins at handholes/manhole in accordance with the Drawings and Specifications.
- (2) Furnishing and installing pre-manufactured handholes, buried fiber optic pull manholes, manhole ring/cover, manhole locking bolts, steps, core drills, conduit plugs, grommets, pipe seals, and grouting; dewatering, excavating, backfilling, and compacting around structures; surface restoration and furnishing and installing marker posts, marker flags, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications
- (3) Where fiber optic conduits are to be installed in tunneled and open trench casing installations, this work shall be paid under Bid Items 12, 15, 18, 20, 22, 24, and 26 and excluded from payment under this item.

- b. Measurement for payment will be linear foot and based on actual installed linear footage of three bundled HDPE conduits and associated appurtenances.

2. Payment:

- a. Linear foot (LF).

G. Item 7: 42-inch Fully Welded Steel Water Pipeline

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) Furnishing and installing 42-inch finished inside diameter, fully welded steel waterline piping including all fittings, couplings, lining, coating, insulating appurtenances, labor, excavation, pipe bedding, backfilling, welding consumables, tracer wire, detectable warning tape, record keeping/as-built documentation and other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- (2) Performing soil management activities in agricultural and non-agricultural areas as required by Specification Section 32 90 10.
- (3) Furnishing and installing cathodic protection test stations, AC mitigation appurtenances, rectifier and ground bed station, joint bonding, wire connection protection, test station boxes, terminal boards, shunts, wire labels, holiday testing, coating testing, record keeping, system testing, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications. The Cathodic Protection Test Station Schedule indicated on the Drawings includes all required test stations under this bid item. Foreign pipeline test stations will be identified and confirmed during construction and will be paid under Bid Item 45.
- (4) Furnishing equipment required to test coatings for imperfections. This shall include holiday test equipment. Contractor shall provide new, calibrated equipment for all testing. Contractor shall provide new, calibrated equipment to the Construction Manager for additional testing.
- (5) Design, labor, equipment, and materials required for the Contractor (and their Cathodic Protection subcontractor) to provide Close Interval Surveys. The survey efforts shall include all preparation, design, testing, documentation, surveys, and record keeping to perform this work per the Drawings and Specifications.
- (6) Locating and potholing existing utilities, power pole support and relocation/ protection of existing utility guy wires, tree relocation, clearing, grubbing, stripping topsoil, segregating and separately stockpiling topsoil, stockpiling other materials, excavation, dewatering, protection and support of existing utilities, furnishing and installation of the pipe, furnishing and installation of all fittings and appurtenances, furnishing and the installation of pipe restraint, pipe welding, weld quality inspections, thermal weld control fittings and procedures, joint wrap, coating replacement and repair, cement mortar lining repair, tracer wire, tracer wire test stations, warning tape, utility locate ball markers, marker posts, furnish and install

imported granular pipe embedment material, CLSM placement and backfill, compacted backfill, processing backfill to appropriate moisture content (as required), removal of excess soil and spoil materials, all extra compaction for backfill beneath surfacing, cleaning, furnishing and installing couplings, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.

- (7) Removal of allowable / approved trees, shrubs, vegetation, and excess excavated materials (spoils) generated from the job site. Excess spoil generated due to the installation of the waterline shall not be placed on site unless noted on the plans or as negotiated with and desired by individual landowners. If a landowner requests disposal of material on their property, a written approval must be obtained and included in construction documentation. Excess spoil generated shall be exported to an off-site location authorized and secured by the Contractor unless negotiated with and wanted by the landowner. The unit price submitted shall include all costs for hauling, trucking, and disposing of excess spoil generated.
- (8) Coordination, mounting, framing, supporting, erecting, and moving for six (6) Owner provided project signs. This shall include locating project signs to be clearly visible to the public and relocating as necessary to correspond with Work as the project progresses.
- (9) Monthly aerial photography. Cost shall be inclusive of all permitting, data collection, and data distribution to the Construction Manager on electronic media.
- (10) Removal and replacement of existing buried and surface irrigation pipelines, storm sewer culverts, and other utilities as shown on the plans. Irrigation pipelines and storm sewer culverts in the way of construction related activities shall be removed and replaced as required to perform the work at no additional cost to the Owner. This includes furnishing new culvert materials as required to make the installations.
 - (a) Works associated with four (4) culverts (Irrigation Culvert, 18" ADS, 24" CMP, and 12" CMP) located in LCR 56 shall be paid separately under Bid Items 33, 34, 35, and 36.
- (11) Any and all other items necessary for a completely functioning waterline and to bring the site to pre-construction conditions which are not specifically called for in other bid items. Any such items shall be at no additional cost to Owner.

b. Measurement for payment will be linear foot as described below:

- (1) Waterline shall be measured for payment on a horizontal plane after installation of the pipe. Where lines are laid to conform to stationed profiles, payment shall be made on linear quantities based on the pipeline stationing as determined by the surveys made after installation. The measurement of a given segment submitted for payment will begin and end at a pipe joint, fitting, or valve.
- (2) The measurement for this item shall stop and start at the ends of tunneled and open trench steel casing pipe installations.
- (3) Measurement for payment for procurement and installation of steel carrier pipe within tunneled or open trenched steel casing pipe installations shall be paid separately under Bid Items 12, 15, 18, 20, 22, 24, and 26 and excluded from payment under this item.

2. Payment:

a. Linear foot (LF).

H. Item 8: Connection to 42-inch Waterline at the Source Water Pump Station Site

1. Measurement:

a. Includes work for, but is not limited to, the following:

- (1) Excavation, dewatering; removal and disposal of new and existing bulkheads; connecting to existing cathodic protection system; draining existing pipe; furnishing and installing pipe, fittings, couplings, restraints, buttstraps, welding, pipe embedment, backfill, compaction, and all other necessary work, materials and equipment required to complete this item in accordance with the Drawings and Specifications.

b. Measurement and payment will be lump sum per each connection.

2. Payment

a. Lump Sum (LS).

I. Item 9: Connection to Segment F.2 42-inch Steel Waterline South of LCR 54

1. Measurement:

a. Includes work for, but is not limited to, the following:

- (1) Excavation, dewatering; removal and disposal of new and existing bulkheads; connecting to existing cathodic protection system; draining existing pipe; furnishing and installing pipe, fittings, couplings, restraints, buttstraps, welding, pipe embedment, backfill, compaction, and all other necessary work, materials and equipment required to complete this item in accordance with the Drawings and Specifications.

- b. Measurement and payment will be lump sum per each connection.

2. Payment

- a. Lump Sum (LS).

J. Items 10, 13, and 16: Shafts

1. Applicable to the following Bid Items:

- a. Item 10: State Highway 1 Tunnel: Shafts
- b. Item 13: Giddings Road Tunnel: Shafts
- c. Item 16: BNSF Railroad Tunnel: Shafts

2. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) The erection and removal of launch and receive shafts including engineering/design, shoring, sheeting, dewatering, excavation, permeation grouting, concrete and rebar, vertical shaft foundations, shaft backfilling, pipe embedment at riser assembly locations, compaction, finish grading, subgrade preparation, and all other related and necessary materials, work, and equipment required to complete this item in accordance with the Drawings and Specifications.

- b. Measurement for payment will be lump sum and shall be made on a Contract Price Earned (CPE) percentage basis for each Item as agreed by the Construction Manager.

3. Payment:

- a. Lump sum (LS).

K. Items 11, 14, 17: Tunnel Excavation and Support

1. Applicable to the following Bid Items:
 - a. Item 11: State Highway 1 Tunnel: Excavation and Support
 - b. Item 14: Giddings Road Tunnel: Excavation and Support
 - c. Item 17: BNSF Railroad Tunnel: Excavation and Support
2. Measurement:
 - a. Includes work for, but is not limited to, the following:
 - (1) Providing engineering/design, pre-installation surveys including building foundation surveys, equipment for tunneling operations, utility monitoring points and instrumentation, furnishing and installing steel casing pipe or erected support, welding, muck removal, existing utility investigation and protection measures, controlling line and grade and meeting tolerances, contact grouting, cathodic protection accessories, wiring, and test stations, and all equipment, materials, and labor as require to construct the work as specified in the Contract Documents.
 - (2) This items shall also include railroad right of entry, inspector, and flagging fees. For bidding purposes Contractor shall assume the fees will be no less than \$2,500 per day.
 - b. Measurement for Payment will be linear foot as measured for the tunnel length installed.
3. Payment:
 - a. Linear foot (LF).

L. Items 12, 15, and 18: Tunnel Carrier Pipe Installation

1. Applicable to the following Bid Items:
 - a. Item 12: State Highway 1 Tunnel: Carrier Pipe Installation
 - b. Item 15: Giddings Road Tunnel: Carrier Pipe Installation
 - c. Item 18: BNSF Railroad Tunnel: Carrier Pipe Installation
2. Measurement:
 - a. Includes work for, but is not limited to, the following:

(1) Furnishing and installing the carrier pipe (fully welded steel pipe) in the casing or erected support, furnishing and installing casing insulators, furnishing and installing end seals, furnishing and installing end wraps, furnishing and installing the fiber optic conduits with preinstalled pull tape in the tunnel, performing fiber optic conduit mandrel testing and furnishing all mandrel testing equipment, annular or backfill grouting, successful testing, and all necessary materials, work, testing, and equipment required to complete this item in accordance with the Drawings and Specifications.

b. Measurement for payment will be linear foot as measured for carrier pipe installed.

3. Payment:

a. Linear foot (LF).

M. Items 19 and 21: LCR 11 and LCR 54 Open Trench Casing Installation

1. Applicable to the following Bid Items:

a. Item 19: LCR 11 (STA 185+88 to STA 186+68): Open Trench Casing Installation

b. Item 21: LCR 54 (STA 313+18 to STA 314+03): Open Trench Casing Installation)

2. Measurement:

a. Includes work for, but is not limited to, the following:

(1) Excavation, dewatering, backfilling, furnishing and installing casing pipe, all skids, insulators, jointing materials welding, cathodic protection accessories, wiring, and test stations, and all other related and necessary materials, work, testing, and equipment required to complete this item in accordance with the Drawings and Specifications.

(2) The 42-inch steel water carrier pipe installations and fiber optic conduit installation for LCR 11 and LCR 54 shall be covered under Bid Items 20 and 22.

(3) LCR 11 and LCR 54 gravel road restoration will be paid under Bid Item 46.

b. Measurement for Payment will be based on linear foot of installed casing.

3. Payment

- a. Linear Foot (LF).

N. Items 23 and 25: Larimer County Canal Open Trench Crossings

1. Applicable to the following Bid Items:

- a. Item 23: Larimer County Canal (STA 66+95): Open Trench Crossing
- b. Item 25: Larimer County Canal (STA 199+35): Open Trench Crossing

2. Measurement:

- a. Includes work for, but is not limited to, the following:
 - (1) Canal company coordination, excavation, dewatering, backfilling, furnishing and installing casing pipe, all skids, insulators, jointing materials welding, cathodic protection accessories, wiring, and test stations, placement of CLSM cutoff walls and encasement, backfilling, clay liner installation, stockpiling and preserving any existing embankment protection and replacing it after clay liner installation, finishing, restoration and any other necessary work, materials, and equipment to complete this item in accordance with the Drawings and Specifications.
 - (2) Fully completing the crossings between November 1 and March 31.
 - (3) The 42-inch steel water carrier pipe installation and fiber optic conduit installation at the canal crossings shall be covered under Bid Items 24 and 26.
- b. Measurement for Payment will be based on lump sum basis per each completed crossing.

3. Payment

- a. Lump Sum (LS).

O. Items 20, 22, 24, and 26: LCR 11, LCR 54, and Larimer County Canal Carrier Pipe Installations

1. Applicable to the following Bid Items:

- a. Item 20: LCR 11 (STA 185+88 to STA 186+68): Carrier Pipe Installation
- b. Item 22: LCR 54 (STA 313+18 to STA 314+03): Carrier Pipe Installation

- c. Item 24: Larimer County Canal (STA 66+63 to STA 67+33): Carrier Pipe Installation
- d. Item 26: Larimer County Canal (STA 199+81 to STA 199+04): Carrier Pipe Installation

2. Measurement:

- a. Includes work for, but is not limited to, the following:
 - (1) Furnishing and installing the carrier pipe (fully welded steel pipe) in the casing or erected support, furnishing and installing casing insulators, furnishing and installing end seals, furnishing and installing end wraps, furnishing and installing the fiber optic conduits with preinstalled pull tape in the tunnel, performing fiber optic conduit mandrel testing and furnishing all mandrel testing equipment, annular or backfill grouting, successful testing, and all necessary materials, work, testing, and equipment required to complete this item in accordance with the Drawings and Specifications.
- b. Measurement for payment will be linear foot as measured for carrier pipe installed.

3. Payment:

- a. Linear foot (LF).

P. Items 27, 28, and 29: Concrete Pipe Encasement

1. Applicable to the following Bid Items:

- a. Item 27: Concrete Pipe Encasement (STA 38+49 to STA 41+15)
- b. Item 28: Concrete Pipe Encasement (STA 95+75 to STA 100+75)
- c. Item 29: Concrete Pipe Encasement (STA 135+94 to STA 137+88)

2. Measurement:

- a. Includes work for, but is not limited to, the following:
 - (1) Excavation, dewatering, backfilling, furnishing, and installing formwork, coordinating required concrete delivery, forming, finishing, curing compound, steel reinforcement, and any other necessary work, materials, and equipment to complete this item in accordance with the Drawings and Specifications.

(2) The fiber optic conduit shall not stop and start at the ends of the concrete encasement and shall be measured continuously through the concrete encasement and paid for under Bid Item 6.

(3) The 42-inch steel water carrier pipe shall not stop and start at the ends of the concrete encasement and shall be measured continuously through the concrete encasement and paid for under Bid Item 7.

b. Measurement for payment for this item will be measured based on the actual number of linear feet of concrete encasement installed as measured along the centerline of the installed pipe.

3. Payment:

a. Linear foot (LF).

Q. Item 30: Combination Air Release / Vacuum Valve and Manway Vault

1. Measurement:

a. Includes work for, but is not limited to, the following:

(1) Furnishing and installation of the vault including excavation, dewatering, concrete, reinforcing steel, pre-cast concrete vault, access hatches, manhole ring/cover, manhole locking bolts, ladder, vent piping, routing of vent piping, combination air release/vacuum valves, shutoff valves, valve operators, air/vac discharge piping, bollards, marker flags, grouting, field painting, backfill and compaction around the vault, surface improvements and restoration, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specification.

(2) The fiber optic conduit shall not stop and start at the valve vault and shall be measured continuously through installation and paid for under Bid Item 6.

b. Measurement for payment will be unit price based the number of vaults installed.

2. Payment:

a. Unit price per each (EA).

R. Item 31: Riser Assembly Vault with Combination Air Release / Vacuum Valves

1. Measurement:

- a. Includes work for, but is not limited to, the following:
 - (1) Furnishing and installation of the riser assembly vault including excavation, dewatering, small diameter appurtenant piping and appurtenances necessary for the full installation of the riser assembly, installation of the combination air release/vacuum valves, shutoff valves, concrete vault, hatches, field painting, steps, backfill and compaction around the vault, testing, surface improvements and restoration, bollards, and any other necessary work, materials, and equipment to complete this item in accordance with the Drawings and Specifications.
 - (2) The fiber optic conduit shall not stop and start at the riser assembly vault and shall be measured continuously through installation and paid for under Bid Item 6.
 - (3) The 42-inch welded steel water pipe, including riser and blind flange, shall not stop and start at the vault and shall be measured continuously through the installation and paid under Bid Item 7.
- b. Measurement for payment will be unit price based on the number of riser assemblies installed.

2. Payment:

- a. Unit price per each (EA).

S. Item 32: Blowoff Assembly

1. Measurement:

- a. Includes work for, but is not limited to, the following:
 - (1) Excavation, dewatering, furnishing and installing all piping, precast manhole sections, fittings, isolation valve, valve box operators, extensions, restraint, cathodic protection anode, concrete support encasement, backfill and compaction, riprap and concrete aprons and rundowns (where indicated on the Drawings), surface improvements and restoration, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- b. Measurement for payment will be unit price based on the number of blowoff assemblies installed.

2. Payment:

- a. Unit price per each (EA).

T. Item 33: Irrigation Pipe Replacement (STA 135+08)

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) Irrigation owner coordination, surveying, excavation, dewatering, bypass pumping, furnishing and installing all piping, couplings, the upstream concrete inlet structure, backfilling, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- (2) LCR 56 replacement and restoration shall be covered under Bid Item 47.

- b. Measurement for Payment will be based on lump sum basis for the completed crossing.

2. Payment

- a. Lump Sum (LS).

U. Item 34: 18" ADS Storm Pipe Replacement (STA 151+15)

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) The replacement of the existing ADS storm pipe with a new 18" CSP culvert including Larimer County coordination, excavation, dewatering, furnishing and installing all piping, inlet/outlet flared end sections, backfilling, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- (2) LCR 56 replacement and restoration shall be covered under Bid Item 47.

- b. Measurement for Payment will be based on lump sum basis for the completed crossing.

2. Payment

- a. Lump Sum (LS).

V. Item 35: 24" CMP Storm Pipe Replacement (STA 157+87)

1. Measurement:

a. Includes work for, but is not limited to, the following:

- (1) The replacement of the existing CMP storm pipe with a new 30" CSP culvert including Larimer County coordination, excavation, dewatering, furnishing and installing all piping, new inlet box, outlet flared end section, downstream reinforced concrete toe wall, grouted riprap run down, backfilling, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- (2) LCR 56 replacement and restoration shall be covered under Bid Item 47.

b. Measurement for Payment will be based on lump sum basis for the completed crossing.

2. Payment

a. Lump Sum (LS).

W. Item 36: 12" CMP Storm Pipe Replacement (STA 166+79)

1. Measurement:

a. Includes work for, but is not limited to, the following:

- (1) The replacement of the existing storm pipe with a new 15" CSP culvert including Larimer County coordination, excavation, dewatering, furnishing and installing all piping, grouted downstream riprap run down, backfilling, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- (2) LCR 56 replacement and restoration shall be covered under Bid Item 47.

b. Measurement for Payment will be based on lump sum basis for the completed crossing.

2. Payment

a. Lump Sum (LS).

X. Item 37: Waterline Filling, Testing, and Dewatering, Test Segment No. 1 (West, STA 10+00 to STA 124+95)

1. Measurement:

a. Includes work for, but is not limited to, the following:

- (1) The development, submittal, and approval of a testing plan, securing water, paying all costs for water, providing hydrostatic testing equipment, completely filling the waterline with clean water, expelling air from the line, coordinating and running the hydrostatic test, retesting as required for successful completion, dewatering the waterline, pumped removal of water from pipeline profile traps (deep tunnel crossings), chemical treatment of the discharge water, chemical treatment equipment, coordination with discharge requirements, testing, record keeping, coordination with the Construction Manager, Engineer, other applicable Owner representatives, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.
- (2) The supply, installation, removal, welding, and grouting of intermediate test bulkheads will be paid for under Bid Item 7. Intermediate temporary test bulkheads shall be placed within 20 feet of the intermediate stations.

b. Measurement for Payment will be based on lump sum basis after the successful filling, testing, and dewatering of the test segment.

2. Payment

a. Lump sum (LS).

Y. Item 38: Waterline Filling, Testing, and Dewatering, Test Segment No. 2 (Central, STA 124+95 to STA 176+52)

1. Measurement:

a. Includes work for, but is not limited to, the following:

- (1) The development, submittal, and approval of a testing plan, securing water, paying all costs for water, providing hydrostatic testing equipment, completely filling the waterline with clean water, expelling air from the line, coordinating and running the hydrostatic test, retesting as required for successful completion, dewatering the waterline, pumped removal of water from pipeline profile traps (deep

tunnel crossings), chemical treatment of the discharge water, chemical treatment equipment, coordination with discharge requirements, testing, record keeping, coordination with the Construction Manager, Engineer, other applicable Owner representatives, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.

- (2) The supply, installation, removal, welding, and grouting of intermediate test bulkheads will be paid for under Bid Item 7. Intermediate temporary test bulkheads shall be placed within 20 feet of the intermediate stations.

- b. Measurement for Payment will be based on lump sum basis after the successful filling, testing, and dewatering of the test segment.

2. Payment

- a. Lump sum (LS).

Z. Item 39: Waterline Filling, Testing, and Dewatering, Test Segment No. 3 (East, STA 176+52 to STA 314+37)

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) The development, submittal, and approval of a testing plan, securing water, paying all costs for water, providing hydrostatic testing equipment, completely filling the waterline with clean water, expelling air from the line, coordinating and running the hydrostatic test, retesting as required for successful completion, dewatering the waterline, pumped removal of water from pipeline profile traps (deep tunnel crossings), chemical treatment of the discharge water, chemical treatment equipment, coordination with discharge requirements, testing, record keeping, coordination with the Construction Manager, Engineer, other applicable Owner representatives, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.

- (2) The supply, installation, removal, welding, and grouting of intermediate test bulkheads will be paid for under Bid Item 7. Intermediate temporary test bulkheads shall be placed within 20 feet of the intermediate stations.

- b. Measurement for Payment will be based on lump sum basis after the successful filling, testing, and dewatering of the test segment.

2. Payment

- a. Lump sum (LS).

AA. Item 40: Monitoring Well Abandonment

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) Removal and abandonment of existing groundwater monitoring wells installed as part of the project's geotechnical investigation including coordinating and permitting with the State Engineer's office on permit closeout. Removal and abandonment to follow requirements of the State Engineer's office.

- b. Measurement for payment will be unit price based on the number of monitoring wells abandoned and closed.

2. Payment:

- a. Unit price per each (EA).

BB. Items 41: Procurement, Shipping, Delivery, and Storage of Loose Items (Steel Pipe)

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) Furnishing and storing loose steel pipe and fittings to be used as needed for field modifications that may be required based on unforeseen field conditions. Actual materials shall include all lined and coated pipe, fittings, and accessories as indicated on the Drawings and Specifications.

- (2) Loose items include:

- (a) Two (2) steel buttstraps for 0.281" wall thickness.
- (b) One (1) 50 ft standard length steel pipe with 0.281" wall thickness.
- (c) Four (4) steel filler rings for each pipe thickness (8 total).

(d) Four (4) 45-degree bends with 0.281" wall thickness.

b. Measurement for payment will be lump sum.

2. Payment:

a. Lump Sum (LS).

CC. Item 42: Procurement, Shipping, Delivery, and Storage of Loose Items (2" ELCO Waterline)

1. Measurement:

a. Furnishing and storing spare pipe, couplings, and valve materials to be used if needed for ELCO waterline relocation.

b. Items include:

(1) 200 feet of 2" IPS Schedule 40 PVC Potable Water 1120 Pipe (XIRTEC).

(2) Four (4) 2" nominal size NSF approved Smith-Blair Blue Epoxy Repair Couplings, 2.34-2.63 OD, Part Number 41100025003003.

(3) Four (4) 2.5" nominal size NSF approved Smith-Blair Blue Epoxy Repair Couplings, 2.88 OD, Part Number 41100028810003.

(4) Two (2) 2" Mueller 2362 Resilient Wedge Gate Valves (MJ x MJ).

c. Payment for any ELCO waterline relocation work will be covered under Bid Item 50A.

2. Payment:

a. Lump Sum (LS).

DD. Item 43: Construction Access (Temporary and Permanent)

1. Measurement:

a. Includes work for, but is not limited to, the following:

(1) Obtaining construction access permits from Larimer County for all access locations, Temporary and Permanent, as shown on the Drawings.

(2) Construction of new temporary and permanent access locations as shown on the Drawings.

- (a) Removal of all temporary access installations shown on the Drawings shall be covered under Bid Item No 48.
 - (3) Site clearing, grubbing, excavation, site rough grading, fine grading, and placement of new aggregate base course and culverts (where shown on the Drawings).
 - (4) Where called for the Drawings, installation of new fence and gates, removal, disposal, and replacement of existing driveway culverts.
 - (5) Attending final inspections with Larimer County and CDOT, and making any necessary adjustments to obtain approval from Larimer County and CDOT.
 - b. Measurement for payment will be unit price based on the number of accesses permitted and constructed.
2. Payment:
- a. Each (EA).
- EE. Item 44: Contractor Quality Control Testing and Reporting
1. Measurement:
- a. Includes work for, but is not limited to, the following:
 - (1) Contractor to perform all Quality Control coordination, testing, and reporting on the project and retain the services of a Certified Independent testing agency.
 - (2) Perform testing on project elements including, but not limited to, concrete, aggregate, pipe bedding and backfill, welding, paint, and all other materials to be incorporated into the Work.
 - (3) Retain the services of an Independent and Certified Welding Inspector (CWI) to inspect and provide written acceptance of all welds. Welding inspector shall be approved and acceptable to Owner, Engineer, and Construction Manager.
 - b. Measurement for payment will be lump sum and shall be made on a Contract Price Earned (CPE) percentage basis.
2. Payment:
- a. Lump Sum (LS).

FF. Item 45: Foreign Pipe Test Stations (STA 32+06, STA 92+36, STA 178+21)

1. Measurement:

a. Includes work for, but is not limited to, the following:

- (1) Perform cathodic protection close interval survey to identify potential stray current implications of foreign metallic pipeline crossings. If deemed necessary based on the close interval survey, foreign pipe test stations shall be installed.
- (2) Furnishing and installing foreign pipe test stations, joint bonding, wire connection protection, test station boxes, terminal boards, shunts, wire labels, holiday testing, coating testing, record keeping, system testing, and all other necessary materials, work and equipment required to complete this item in accordance with the Drawings and Specifications.

b. Measurement for payment will be unit price based on the actual number of foreign pipeline test stations installed.

2. Payment:

a. Unit price per each (EA).

GG. Item 46: Gravel Road Replacement and Restoration – LCR 11, LCR 54, and Driveway Crossings

1. Measurement:

a. Includes work for, but is not limited to, the following:

- (1) Replacing and restoring gravel roads and driveways that are crossed and disturbed as part of the work. Replacing and restoring gravel roads that are crossed as part of the work shall be in accordance with Larimer County standards and requirements and shall include, but not limited to excavating and disposing of existing driveway and road base, providing water, providing aggregate base, grading, proof rolling, and establishing a 5% crown. The replacement and restoration of LCR 54 shall also include scarifying, initial magnesium chloride application, compaction, and final magnesium. Contractor shall reference the Drawings for further information on crossings of LCR 11 and LCR 54.

b. Measurement for payment will be unit price per square yard of road replacement and restoration.

2. Payment:

- a. Unit price per square yard (SY).

HH. Item 47: Gravel Road Replacement and Restoration – LCR 56

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) Replacing and restoring LCR 56 where disturbed and impacted as part of the Work in accordance with Larimer County standards and requirements including, but not limited to, excavating and disposing of existing roadway base, providing water, providing aggregate base, grading, establishing a 5% crown, scarifying, initial magnesium chloride application, compaction, proof rolling, and final magnesium application. Contractor shall reference the Drawings for further information on work within LCR 56.

- b. Measurement for payment will be unit price per square yard of road replacement and restoration.

2. Payment:

- a. Unit price per square yard (SY).

II. Item 48: Surface Restoration and Seeding

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) Rut removal, fine grading, rock removal, topsoil replacement and preparation, furnishing and installing seed, mulch, tackifier, plantings, as well as maintenance, watering, mowing, post-construction weed spraying, seed reapplication, fence replacement, ditch relocations, culvert replacements, removal of all temporary construction accesses and vehicle tracking control pads and all other necessary materials, work, and equipment required to complete this item in accordance with the Drawings and Specifications.
- (2) Coordination with the Project's Construction Manager, Environmental Specialist, and Soil Specialist on the restoration restrictions and requirements included in the Drawings and Specifications.

- b. All requirements and restrictions located in Specification Section 32 90 10 associated with site protection, clearing, grubbing, stripping, and soil management shall be covered and paid for under Bid Items 3 and 7. Contractor shall be aware of the requirements associated with wetlands, waters, and agricultural areas.
 - c. Measurement for payment will be unit price per acre of surface disturbed and restored.
 - 2. Payment:
 - a. Unit price per acre (AC).
- JJ. Item 49A: Gravel Road Maintenance and Restoration Allowance – LCR 56
 - 1. Measurement:
 - a. Includes work for, but is not limited to, the following: Changes in the Work not involving an adjustment in the Contract Sum or an extension of the Contract Time and consistent with the intent of the Contract Documents and paid to the Contractor through use of this allowance item.
 - (1) Use of this allowance item shall be for maintenance and/or restoration of LCR 56 that is required above and beyond Work covered under Bid Item 47.
 - (2) Contractor shall not use any Larimer County gravel roads other than:
 - (a) LCR 56 between State Highway 1 and the BNSF Railroad.
 - (b) LCR 54 between Giddings Road (LCR 9) and Segment F.1's easterly construction limits.
 - (3) Should the maintenance, repair, or restoration of LCR 11 or LCR 13 outside the limits of construction be required as a result of Contractor use, the Contractor shall be fully responsible for all costs and efforts associated with dust control, maintenance, repair, and restoration to the satisfaction of Larimer County.
 - (4) Should the maintenance, repair, or restoration of LCR 54 or LCR 56 east of the BNSF Railroad be required as a result of Contractor use, the Contractor shall be fully responsible for all costs and efforts associated with dust control, maintenance, repair, and restoration to the satisfaction of Larimer County.

- b. Executed Authorization of Allowance Account must be agreed to by the Construction Manager, the Owner, and the Contractor in order to use this allowance item.
- c. Measurement and payment will be in accordance with the Allowance Administration procedures described in Part 3.

2. Payment:

- a. Dollar (DOL).

KK. Item 50A: ELCO Waterline Relocation Allowance

1. Measurement:

- a. Includes work for, but is not limited to, the following: Changes in the Work not involving an adjustment in the Contract Sum or an extension of the Contract Time and consistent with the intent of the Contract Documents and paid to the Contractor through use of this allowance item.
 - (1) Unanticipated relocation of portions of an existing 2" ELCO waterline and appurtenances within LCR 56 right-of-way as required for construction of the 42-inch steel waterline.
 - (2) Installation of new 2" ELCO waterline and appurtenances including reconnections to the existing ELCO waterline, bedding, backfill and compaction, and all other necessary work and equipment required to complete this item in accordance with the Drawings and Specifications.
 - (3) Coordination with East Larimer County (ELCO) Water District.
 - (4) Procurement and storage of loose materials shall be covered under Bid Item 42.
 - (5) LCR 56 replacement and restoration shall be covered under Bid Item 47.
- b. Executed Authorization of Allowance Account must be agreed to by the Construction Manager, the Owner, and the Contractor in order to use this allowance item.
- c. Measurement and payment will be in accordance with the Allowance Administration procedures described in Part 3.

2. Payment:

- a. Dollar (DOL).

LL. Item 51A: Owner Authorized Drain Tile Conflict Allowance

1. Measurement:

- a. Includes work for, but is not limited to, the following: Changes in the Work not involving an adjustment in the Contract Sum or an extension of the Contract Time and consistent with the intent of the Contract Documents and paid to the Contractor through use of this allowance item.
 - (1) Removal of existing drain tile pipeline within the work limits as required for construction of the 42-inch steel waterline.
 - (2) Replacement of the drain tile with new PVC pipe including pipe, fittings, and flexible connections to existing pipe.
 - (3) In the event of a conflict, the replacement pipeline may be routed above the 42-inch waterline with a vertical cleanout.
 - (4) In the event of no conflict, the replacement pipeline may be installed on the original drain tile line and grade.
- b. Executed Authorization of Allowance Account must be agreed to by the Construction Manager, the Owner, and the Contractor in order to use this allowance item.
- c. Measurement and payment will be in accordance with the Allowance Administration procedures described in Part 3.

2. Payment:

- a. Dollar (DOL)

MM. Item 52A: Owner Authorized Contaminated Soils Removal and Replacement Allowance

1. Measurement:

- a. Includes work for, but is not limited to, the following: Changes in the Work not involving an adjustment in the Contract Sum or an extension of the Contract Time and consistent with the intent of the Contract Documents and paid to the Contractor through use of this allowance item.
 - (1) Implementing the requirements of the Materials Management Plan, determining an appropriate disposal facility, providing equipment, labor, and materials for the proper removal and disposal of

contaminated soils including all trucking, importing clean soils, and all other necessary materials, work, and equipment required to complete this item in accordance with the Drawings and Specifications.

- (2) In areas where contaminated soil is encountered, dewatering, treatment, and/or disposal of contaminated groundwater shall take place prior to discharge and be covered under Allowance Item 54A.
- (3) See requirements of the Materials Management Plan included as an Attachment.

- b. Executed Authorization of Allowance Account must be agreed to by the Construction Manager, the Owner, and the Contractor in order to use this allowance item.
- c. Measurement and payment will be in accordance with the Allowance Administration procedures described in Part 3.

2. Payment:

- a. Dollar (DOL).

NN. Item 53A: Owner Authorized Restoration Allowance

1. Measurement:

- a. Includes work for, but is not limited to, the following: Changes in the Work not involving an adjustment in the Contract Sum or an extension of the Contract Time and consistent with the intent of the Contract Documents and paid to the Contractor through use of this allowance item.
 - (1) Use of this allowance shall strictly be for final surface restoration that is required above and beyond restoration requirements required by the Drawings and Specifications and covered by other Bid Items.
 - (2) All efforts associated with permanent seeding and final restoration as shown and specified by the Contractor Documents shall be covered under Bid Item 48 and will not be covered by this allowance item.
- b. Executed Authorization of Allowance Account must be agreed to by the Construction Manager, the Owner, and the Contractor in order to use this allowance item.
- c. Measurement and payment will be in accordance with the Allowance Administration procedures described in Part 3.

2. Payment:

- a. Dollar (DOL).

OO. Item 54A: Owner Authorized Remediation / Treatment of Dewatering Discharge Allowance

1. Measurement:

- a. Includes work for, but is not limited to, the following: Changes in the Work not involving an adjustment in the Contract Sum or an extension of the Contract Time and consistent with the intent of the Contract Documents and paid to the Contractor through use of this allowance item.
- (1) Providing all labor and materials for the planning, permitting, proper treatment or remediation and testing of dewatering discharges as required by the Colorado Department of Public Health and Environment (CDPHE) under the Water Quality Control Division's Dewatering General Permit Number COG-317000, Short-Term Remediation Activities Discharges.
 - (2) In areas where contaminated groundwater is encountered, dewatering, treatment, and testing shall take place prior to discharge as required by CDPHE.
 - (3) All efforts associated with dewatering discharges under CDPHE General Permit Number COG-080000 shall be covered under other Bid Items.
- b. Executed Authorization of Allowance Account must be agreed to by the Construction Manager, the Owner, and the Contractor in order to use this allowance item.
- c. Measurement and payment will be in accordance with the Allowance Administration procedures described in Part 3.

2. Payment:

- a. Dollar (DOL).

PP. Item 55A: Owner Authorized Utility Conflict Allowance

1. Measurement:

- a. Includes work for, but is not limited to, the following: Changes in the Work not involving an adjustment in the Contract Sum or an extension of the

Contract Time and consistent with the intent of the Contract Documents and paid to the Contractor through use of this allowance item.

- (1) Coordinating with Construction Manager to identify and confirm utility size, type, material, ownership, and whether utility is active or abandoned.
 - (2) Allowance can be used for any utilities that:
 - (a) The Contractor locates and were not identified during design as part of the requirements listed in Specification Sections 02 01 20 and 02 32 19.
 - (b) The depths of utilities are unknown as shown on the Contract Drawings.
 - (3) Coordinating with Construction Manager, Owner, and Engineer to develop a vertical pipeline adjustment plan.
 - (4) Providing all labor and materials for adjusting the pipeline's profile including additional trenching, backfilling, compaction, welding, and grouting.
 - (5) All unanticipated work associated with East Larimer County (ELCO) Water District's 2-inch waterline located in LCR 56 will be covered under Bid Allowance Item 50A.
- b. Executed Authorization of Allowance Account must be agreed to by the Construction Manager, the Owner, and the Contractor in order to use this allowance item.
 - c. Measurement and payment will be in accordance with the Allowance Administration procedures described in Part 3.

2. Payment:

- a. Dollar (DOL)

QQ. Item 56A: Owner Authorized Pre-Construction Weed Control Allowance

1. Measurement:

- a. Includes work for, but is not limited to, the following:

- (1) Coordinating with Construction Manager to understand the application limits and timing of Owner directed pre-construction weed control.
 - (2) Providing all labor and materials for applying a Larimer County-approved weed control product in pre-determined areas. Applications may involve precisely timed applications in the spring and fall prior to topsoil disturbance.
 - b. Executed Authorization of Allowance Account must be agreed to by the Construction Manager, the Owner, and the Contractor in order to use this allowance item.
 - c. Measurement and payment will be in accordance with the Allowance Administration procedures described in Part 3.
2. Payment:
- a. Dollar (DOL)

PART 2 - MATERIALS

NOT USED

PART 3 - EXECUTION

3.01. ALLOWANCE ADMINISTRATION

- A. The following procedure applies to all allowance items in the Segment F.1 bid schedule. Allowance amounts and allowance items remain as listed in the bid schedule.
 1. Written authorization is required before performing allowance work. The Contractor shall submit a written request to the Construction Manager describing the work, the location by segment and station, the applicable allowance item, the estimated cost, and any schedule impact, with supporting documentation.
 2. The Owner, or the Construction Manager with the Owner's concurrence, will issue a written Authorization of Allowance Account, executed by the Construction Manager, the Owner, and the Contractor, establishing the authorized scope and not-to-exceed amount before the allowance work proceeds. Work performed against an allowance item without prior written authorization is not eligible for payment.

3. Authorized allowance work will be measured and paid at 'Actual Field Cost' as defined in the General Conditions, with all required evidence and data submitted to and accepted by the Construction Manager.
4. Allowances are Owner-controlled amounts. There is no guarantee of use, compensation, or profit on allowance items, and no payment will be made for unused allowance amounts.
5. Each authorization will be charged to the applicable allowance item as identified in the Authorization.

END OF SECTION

SECTION 01 31 19

PROJECT MEETINGS

PART 1 - GENERAL

1.01. OVERVIEW

- A. Project meeting requirements for all Work, including Segment F.1, are specified in Segment F.2 Specification Section 01 31 19, Project Meetings. One set of project meetings, chaired by the Construction Manager, will be conducted for the combined Work of Segments F.1 and F.2. References elsewhere in the Segment F.1 Specifications to Section 01 31 19 are satisfied through the referenced Segment F.2 section.

PART 2 - MATERIALS

(not used)

PART 3 - EXECUTION

(not used)

END OF SECTION

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SECTION 01 32 16

CPM CONSTRUCTION SCHEDULE REQUIREMENTS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. Progress schedule requirements for all Work, including Segment F.1, are specified in Segment F.2 Specification Section 01 32 16, Construction Progress Schedule, which governs the combined Work. One integrated progress schedule covering Segments F.1 and F.2, with activities coded by segment, is required under that Section. References elsewhere in the Segment F.1 Specifications to Section 01 32 16 are satisfied through the referenced Segment F.2 section.

PART 2 - MATERIALS

(not used)

PART 3 - EXECUTION

(not used)

END OF SECTION

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SECTION 01 32 33

CONSTRUCTION PHOTO AND VIDEO REQUIREMENTS

PART 1 - GENERAL

1.01. OVERVIEW

- A. The intent of the photos and video is to provide a visual log pre-construction conditions, work completed, and post-construction conditions. Photographs of the site shall be taken prior to, during, after the project.
- B. The Contractor shall be responsible for taking pre-construction videos and photographs to thoroughly document existing field conditions prior to any site preparation activities.
- C. The Contractor shall be responsible for taking post-construction videos and photographs to thoroughly document post-construction field conditions were returned to pre-construction conditions.
- D. The Contractor shall be responsible for taking daily digital photographs of work in progress as a record of activities and major construction events. Day and date camera functions shall be enabled. Photo files shall be saved in *.jpg format.
- E. Photos and video shall be stored electronically and submitted upon completion of the project.
- F. The Contractor shall provide Owner with a pre-project video capture existing conditions of the construction corridor in and near existing road right-of-way as required by the Owner will transmit video to Larimer County as part of obtaining the project's Development Construction Permit (DCP). Contractor shall also incorporate the pre-project video as part of the pre-construction or initial road inventory submittal required by Larimer County.
- G. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix Conditions of Approval Nos. 32, 37, and 67 included with the Project Manual.

1.02. SUBMITTALS

- A. Photographs
 - 1. Submit one copy of high-resolution digital images weekly with each image having a minimum file size of 3 MB (3,000 KB). The production of larger file sizes with higher resolution is encouraged.

B. Video Recordings

1. Submit two (2) copies, including updated copy of project video log, weekly.

C. Monthly Aerial Photography

1. The Contractor shall submit aerial videos on a monthly basis. provide aerial photography of all active work areas on a monthly basis. Collection of aerial photography shall be done professionally and legally. The Contractor may elect to retain an outside service or utilize Contractor furnished drones. Cost of monthly aerial photography shall be inclusive of pipeline installation.

PART 2 - MATERIALS

NOT USED

PART 3 - EXECUTION

3.01. CONSTRUCTION PHOTOGRAPHS AND VIDEOS

A. General

1. The Contractor shall document all phases of the Project including preconstruction, construction progress, and post-construction daily.
2. The photographs shall be high resolution and wide-angle to capture overall views of the work as well as close-up to capture details.
3. Photographs shall be indexed by Segment (F.1 or F.2), station, property, and date.

B. Photography or videography shall only be performed by the Contractor, Owner, and Engineer. Photos and videos by any persons other than the Contractor, Owner, and Engineer is prohibited and it is the Contractor's responsibility to manage the Project site to control photography and video documentation.

C. The Owner or Construction Manager reserves the right to select subject matter and vantage points from which photographs and videos are to be taken.

1. Digital Images and Videos

- a. No post-session electronic editing of images or videos is allowed. Stored images and videos shall be native as captured without cropping or other edits.

D. Preconstruction and Post-Construction Photos

1. After Effective Date of the Agreement and before Work at Site is started, and again upon issuance of Substantial Completion, take a minimum of 250 photographs of the Site and property adjacent to perimeter of Site.
2. Emphasis shall be directed to structures both inside and outside the Site.

E. Construction Progress Photos

1. Photographically demonstrate progress of construction, showing every aspect of Site and adjacent properties as well as interior and exterior of new or impacted structures.
2. Weekly: Take a minimum of 50 high-resolution color photographs to document daily activities.
3. Monthly:
 - a. Take a minimum of 50 high-resolution color photographs to document daily activities to document monthly progress on the Project.
 - b. Provide aerial photography of all active work areas on a monthly basis. Collection of aerial photography shall be done professionally and legally. The Contractor may elect to retain an outside service or utilize Contractor furnished drones. Cost of monthly aerial photography shall be inclusive of pipeline installation.
4. Documentation
 - a. Digital Images
 - (1) Electronic image shall have date taken embedded into image.
 - (2) Archive using a commercially available photo management system that provides listing of photographs including date, keyword description, and direction of photograph.
 - (3) Label daily, weekly, and monthly file folders with Project and Owner's name, day, month, and year images were taken.

3.02. AUDIO-VIDEO RECORDINGS

- A. Prior to beginning the Work on Site or of a particular area of the Work, and within 10 days following date of Substantial Completion, video Site and property adjacent to Site.

- B. In the case of preconstruction recording, no work shall begin in the area prior to Owner or Construction Manager's review and approval of content and quality of video for that area.
 - C. Video emphasis shall be directed to physical condition of existing vegetation, structures, and road pavements and surface within pipeline alignment and areas adjacent to and within the right-of-way or easement, and on Contractor storage and staging areas.
 - D. Video shall be high quality with sound.
 - E. Video:
 - F. Produce bright, sharp, and clear videos with accurate colors, free of distortion and other forms of picture imperfections.
 - a. Electronically, and accurately display the month, day, year, and time of day of the recording.
2. Audio:
- a. Audio documentation shall be done clearly, precisely, and at a moderate pace.
 - b. Indicate date, project name, and a brief description of the location of recording, including:
 - (1) Facility name.
 - (2) Street names or easements.
 - (3) Addresses of private property.

3.03. DIRECTION OF COVERAGE.

1. Documentation:
- a. Project name.
 - b. Name of street(s) or easement(s) included.
 - c. Location by project stationing, if applicable.
 - d. Date and time of coverage.
 - e. Project Video Log.

END OF SECTION

SECTION 01 33 00

SUBMITTALS

PART 1 - GENERAL

1.01. DEFINITIONS

- A. Action Submittal: Written and graphic information submitted by Contractor that requires Engineer's approval.
- B. Deferred Submittal: Information submitted by Contractor for portions of design that are to be submitted to permitting agency for approval prior to installation of that portion of the Work, along with Engineer's review documentation that submittal has been found to be in general conformance with Project's design.
- C. Informational Submittal: Information submitted by Contractor that requires Engineer's review and determination that submitted information is in accordance with the Conditions of the Contract.

1.02. PROCEDURES

- A. Reference General Conditions for additional information.
- B. Electronic Submittals: Submittals shall, unless specifically accepted, be made in electronic format.
 - 1. Each submittal shall be an electronic file in Adobe Acrobat Portable Document Format (PDF). Use the latest version available at time of execution of the Agreement.
 - 2. Electronic files that contain more than 10 pages in PDF format shall contain internal bookmarking from an index page to major sections of the document.
 - 3. PDF files shall be set to open "Bookmarks and Page" view.
 - 4. Add general information to each PDF file, including title, subject, author, and keywords.
 - 5. PDF files shall be set up to print legibly at 8.5-inch by 11-inch, 11-inch by 17-inch, or 22-inch by 34-inch. No other paper sizes will be accepted.
 - 6. Submit new electronic files for each resubmittal.
 - 7. Include a copy of the Transmittal of Contractor's Submittal form, located at end of section, with each electronic file.

8. Construction Manager will reject submittal that is not electronically submitted, unless specifically accepted.
9. Provide Construction Manager with authorization to reproduce and distribute each file as many times as necessary for Project documentation.
10. Detailed procedures for handling electronic submittals will be discussed at the preconstruction conference.
 - a. Contractor shall use construction management software provided by the Construction Manager.
 - b. Construction management software training will be provided by the Construction Manager.

C. Transmittal of Submittal:

1. Contractor shall:
 - a. Review each submittal and check for compliance with Contract Documents.
 - b. Stamp each submittal with uniform approval stamp before submitting to Construction Manager.
 - (1) Stamp to include Project name, submittal number, Specification number, Contractor's reviewer name, date of Contractor's approval, and statement certifying submittal has been reviewed, checked, and approved for compliance with Contract Documents.
 - (2) Construction Manager will not have Engineer review submittals that do not bear Contractor's approval stamp and will return them without action.
2. Complete, sign, and transmit with each submittal package, one Transmittal of Contractor's Submittal in format approved by Construction Manager.
3. Identify each submittal with the following:
 - a. Numbering and Tracking System:
 - (1) Sequentially number each submittal.
 - (2) Resubmission of submittal shall have original number with sequential alphabetic suffix.
 - b. Specification section and paragraph to which submittal applies.

- c. Project title and Thornton's project number.
 - d. Date of transmittal.
 - e. Names of Contractor, Subcontractor or Supplier, and manufacturer as appropriate.
- 4. Identify and describe each deviation or variation from Contract Documents.
- D. Format:
 - 1. Do not base Shop Drawings on reproductions of Contract Documents.
 - 2. Package submittal information by individual specification section. Do not combine different specification sections together in submittal package, unless otherwise directed in specification.
 - 3. Present in a clear and thorough manner and in sufficient detail to show kind, size, arrangement, and function of components, materials, and devices, and compliance with Contract Documents.
 - 4. Index with labeled tab dividers in orderly manner.
- E. Timeliness: Schedule and submit in accordance with Schedule of Submittals and requirements of individual specification sections.
- F. Processing Time:
 - 1. Time for review shall commence on the Construction Manager's receipt of submittal.
 - 2. Construction Manager will act upon Contractor's submittal and transmit to Engineer within two (2) business days of receipt from Contractor. Engineer will return submittals and/or resubmittals within 14 calendar days of receipt.
 - 3. Resubmittals will be subject to same review time.
 - 4. No adjustment of Contract Times or Price will be allowed as a result of delays in progress of Work caused by rejection and subsequent resubmittals.
- G. Resubmittals: Clearly identify each correction or change made.
- H. Incomplete Submittals:
 - 1. Construction Manager will return entire submittal for Contractor's revision if preliminary review deems it incomplete.

2. When any of the following are missing, submittal will be deemed incomplete:

- a. Contractor's review stamp; completed and signed.
- b. Transmittal of Contractor's Submittal; completed and signed.
- c. Insufficient number of copies.

I. Submittals not required by Contract Documents:

- 1. Will not be reviewed and will be returned stamped "Not Subject to Review."
- 2. Construction Manager will keep one copy and return submittal to Contractor.

1.03. ACTION SUBMITTALS

A. Prepare and submit Action Submittals required by individual specification sections.

B. Shop Drawings:

- 1. Copies: Submit in digital .pdf format.
- 2. Identify and Indicate:
 - a. Applicable Contract Drawing and Detail number, products, units and assemblies, and system or equipment identification or tag numbers.
 - b. Equipment and Component Title: Identical to title shown on Drawings.
 - c. Critical field dimensions and relationships to other critical features of Work. Note dimensions established by field measurement.
 - d. Project-specific information drawn accurately to scale.
- 3. Manufacturer's standard schematic drawings and diagrams as follows:
 - a. Modify to delete information that is not applicable to the Work.
 - b. Supplement standard information to provide information specifically applicable to the Work.
- 4. Product Data: Provide as specified in individual specifications.
- 5. Deferred Submittal: See Drawings for list of deferred submittals.
 - a. Contractor-design drawings and product data related to permanent construction.

- (1) Written and graphic information.
 - (2) Drawings.
 - (3) Cut sheets.
 - (4) Data sheets.
 - (5) Action item submittals requested in individual specification section.
- b. Prior to installation of indicated structural or nonstructural element, equipment, distribution system, or component or its anchorage, submit required supporting data and drawings for review and acceptance by Engineer. Documentation of review and approval provided on Engineer's comment form, along with completed submittal, shall be filed with permitting agency by Contractor and approved by permitting agency prior to installation.
6. Foreign Manufacturers: When proposed, include names and addresses of at least two companies that maintain technical service representatives close to Project.

C. Samples:

1. Copies: Two, unless otherwise specified in individual specifications.
2. Preparation: Mount, display, or package Samples in manner specified to facilitate review of quality. Attach label on unexposed side that includes the following:
 - a. Manufacturer name.
 - b. Model number.
 - c. Material.
 - d. Sample source.
3. Manufacturer's Color Chart: Units or sections of units showing full range of colors, textures, and patterns available.
4. Full-size Samples:
 - a. Size as indicated in individual specification section.
 - b. Prepared from same materials to be used for the Work.
 - c. Cured and finished in manner specified.

- d. Physically identical with product proposed for use.
- D. Action Submittal Dispositions: Engineer will review, comment, stamp, and return to Construction Manager to distribute as noted:
 - 1. No Exceptions Taken:
 - a. Contractor may incorporate product(s) or implement Work covered by submittal.
 - b. Distribution: Electronic.
 - 2. Make Corrections Noted:
 - a. Contractor may incorporate product(s) or implement Work covered by submittal, in accordance with Engineer's notations.
 - b. A resubmittal is not required.
 - c. Distribution: Electronic
 - 3. Revise and Resubmit:
 - a. Contractor may not incorporate product(s) or implement Work covered by the submittal. Contractor to resubmit with new or revised product(s) or Work meeting the contract requirements.
 - b. Distribution: Electronic.
 - 4. Rejected:
 - a. Product(s) or Work are rejected and shall not be incorporated. Contractor to resubmit product(s) or Work meeting the contract requirements.
 - b. Distribution: Electronic

1.04. INFORMATIONAL SUBMITTALS

- A. General:
 - 1. Copies: Submit electronic copies, unless otherwise indicated in individual specification section.
 - 2. Refer to individual specification sections for specific submittal requirements.
 - 3. Engineer will review each submittal. If submittal meets conditions of the Contract, Engineer will forward to Construction Manager for distribution to appropriate

parties. If Engineer determines submittal does not meet conditions of the Contract and is therefore considered unacceptable, Engineer will notify Construction Manager who will provide comments to Contractor and require that the submittal be corrected and resubmitted.

B. Certificates:

1. General:

- a. Provide notarized statement that includes signature of entity responsible for preparing certification.
- b. Signed by officer or other individual authorized to sign documents on behalf of that entity.

2. Welding: In accordance with individual specification sections.

3. Installer: Prepare written statements on manufacturer's letterhead certifying installer complies with requirements as specified in individual specification section.

4. Material Test: Prepared by qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements.

5. Certificates of Successful Testing or Inspection: Submit when testing or inspection is required by Laws and Regulations or governing agency or specified in individual specification sections.

6. Manufacturer's Certificate of Compliance: In accordance with Section 01 61 00, Common Product Requirements.

7. Manufacturer's Certificate of Proper Installation: In accordance with Section 01 43 33, Manufacturers' Field Services.

C. Construction Photographs and Video: As required to document pre- and post-construction conditions and construction progress including areas within and adjacent to Larimer County road right-of-way.

D. Closeout Submittals: As required to provide complete record of construction.

E. Contractor-design Data (related to temporary construction):

1. Written and graphic information.
2. List of assumptions.

3. List of performance and design criteria.
 4. Summary of loads or load diagram, if applicable.
 5. Calculations.
 6. List of applicable codes and regulations.
 7. Name and version of software.
 8. Information requested in individual specification section.
- F. Deferred Submittals: See Drawings for list of deferred submittals.
1. Contractor-design data related to permanent construction:
 - a. List of assumptions.
 - b. List of performance and design criteria.
 - c. Summary of loads or load diagram, if applicable.
 - d. Calculations.
 - e. List of applicable codes and regulations.
 - f. Name and version of design software.
 - g. Factory test results.
 - h. Informational submittals requested in individual specification section.
 2. Prior to installation of indicated structural or nonstructural element, equipment, distribution system, or component or its anchorage, submit calculations and test results of Contractor-designed components for review by Engineer. Documentation of review and indication of compliance with general design intent and project criteria provided on Engineer's comment form as meets conditions of the Contract, along with completed submittal, shall be filed with permitting agency by Contractor and approved by permitting agency prior to installation.
- G. Manufacturer's Instructions: Written or published information that documents manufacturer's recommendations, guidelines, and procedures in accordance with individual specification section.
- H. Operation and Maintenance Data: Provide complete O&M data.
- I. Payment:

1. Application for Payment: In accordance with General Conditions – Progress Payments.
 2. Schedule of Values: In accordance with General Conditions – Progress Payments.
 3. Schedule of Estimated Progress Payments: In accordance with Special Conditions – Contractor’s Schedule of Work.
- J. Quality Control documentation: As required in Section 01 45 16.
- K. Schedules:
1. Schedule of Submittals: Prepare separately or in combination with Progress Schedule as specified in Special Conditions – Contractor’s Schedule of Work.
 - a. Show for each, at a minimum, the following:
 - (1) Specification section number.
 - (2) Identification by numbering and tracking system as specified under Paragraph Transmittal of Submittal.
 - (3) Estimated date of submission, including reviewing and processing time.
 - b. On a monthly basis, submit updated Schedule of Submittals to Construction Manager if changes have occurred or resubmittals are required.
 2. Progress Schedules: In accordance with Special Conditions – Contractor’s Schedule of Work.
- L. Special Guarantee: Supplier’s written guarantee as required in individual specification sections.
- M. Statement of Qualification: Evidence of qualification, certification, or registration as required in Contract Documents to verify qualifications of professional land surveyor, engineer, materials testing laboratory, specialty Subcontractor, trade, Specialist, consultant, installer, and other professionals.
- N. Submittals Required by Laws, Regulations, and Governing Agencies:
1. Promptly submit notifications, reports, certifications, payrolls, and otherwise as may be required, directly to the applicable federal, state, or local governing agency or their representative.

2. Transmit to Construction Manager for Thornton's records one copy of correspondence and transmittals (to include enclosures and attachments) between Contractor and governing agency.

O. Test, Evaluation, and Inspection Reports:

1. General: Shall contain signature of person responsible for test or report.
2. Factory:
 - a. Identification of product and specification section, type of inspection or test with referenced standard or code.
 - b. Date of test, Project title and number, and name and signature of authorized person.
 - c. Test results.
 - d. If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.
 - e. Provide interpretation of test results, when requested.
 - f. Other items as identified in individual specification sections.
3. Field:
 - a. As a minimum, include the following:
 - (1) Project title and number.
 - (2) Date and time.
 - (3) Record of temperature and weather conditions.
 - (4) Identification of product and specification section.
 - (5) Type and location of test, Sample, or inspection, including referenced standard or code.
 - (6) Date issued, testing laboratory name, address, and telephone number, and name and signature of laboratory inspector.
 - (7) If test or inspection deems material or equipment not in compliance with Contract Documents, identify corrective action necessary to bring into compliance.

(8) Provide interpretation of test results, when requested by Engineer.

(9) Other items as identified in individual specification sections.

P. Testing and Startup Data: In accordance with applicable specifications.

Q. Training Data: In accordance with Applicable specifications.

1.05. SUBSTITUTIONS

A. Substitution and or-equal requests, including requests involving pipe materials, linings, and coatings, are governed by the General Conditions, the applicable technical Specification Sections, and the bidding requirements. The administrative submittal procedures of this Section do not authorize substitutions, and processing of a submittal does not constitute approval of a substitution.

1.06. SUPPLEMENTS

A. The supplements listed below, following “End of Section”, are part of this specification.

1. Forms: Transmittal of Contractor’s Submittal.

PRODUCTS (NOT USED)

EXECUTION (NOT USED)

END OF SECTION



SEGMENT F.1

TRANSMITTAL OF CONTRACTOR'S SUBMITTAL
(ATTACH TO EACH SUBMITTAL)

DATE: _____

TO: _____ _____ _____ _____ FROM: _____ Contractor	Submittal No.: _____ ☐ New Submittal ☐ Resubmittal Project: _____ Project No.: _____ Specification Section No.: _____ (Cover only one section with each transmittal) Schedule Date of Submittal: _____								
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">SUBMITTAL TYPE:</td> <td style="width: 33%;">☐ Shop Drawing</td> <td style="width: 33%;">☐ Sample</td> <td style="width: 33%;">☐ Informational</td> </tr> <tr> <td></td> <td>☐ Deferred</td> <td></td> <td></td> </tr> </table>		SUBMITTAL TYPE:	☐ Shop Drawing	☐ Sample	☐ Informational		☐ Deferred		
SUBMITTAL TYPE:	☐ Shop Drawing	☐ Sample	☐ Informational						
	☐ Deferred								

The following items are hereby submitted:

Number of Copies	Description of Item Submitted (Type, Size, Model Number, Etc.)	Spec. and Para. No.	Drawing or Brochure Number	Contains Variation to Contract	
				No	Yes

Contractor hereby certifies that: 1) Contractor has complied with the requirements of the Contract Documents in preparation, review, and submission of designated Submittal and; 2) the Submittal is complete and in accordance with the Contract Documents and requirements of laws, regulations and governing agencies.

By: _____
Contractor (Authorized Signature)

SECTION 01 35 29

HEALTH AND SAFETY

PART 1 - GENERAL

1.01. DESCRIPTION

- A. Contractor shall reference Thornton Water Project Segment F.2 Specification Section 01 35 29 Health and Safety (HDR Engineering).

END OF SECTION

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SECTION 01 41 10

COORDINATION OF WORK, PERMITS, AND REGULATIONS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section provides an overview of the project and generally describes the project's coordination activities, permits, restrictions and regulations.

1.02. COORDINATION AND APPROVAL AUTHORITY

- A. For all Work under this Contract (Segments F.1 and F.2):
 - 1. The Owner's Construction Manager is the Contractor's single point of contact for administrative routing and processing, including submittal routing, allowance authorizations, workhour and extended-hours requests, and permit and DCP coordination;
 - 2. The Engineer of Record for each segment retains responsibility for technical review and action on submittals and other design-related matters for that segment.
 - 3. Authorities Having Jurisdiction (AHJs), meaning the federal, state, county, and municipal agencies that issue permits or approvals for the Work (including Larimer County, Weld County, the Colorado Department of Public Health and Environment, and the Colorado Department of Transportation), retain sole authority over their permits and approvals. This paragraph allocates administrative routing only and does not modify the roles, responsibilities, or authorities established elsewhere in the Contract Documents. Terms retain the meanings given in the General Conditions and each segment's Specifications.

1.03. GENERAL NATURE OF THE WORK

- A. The work involves installation of a forty-two (42) inch internal diameter welded steel raw water pipeline for the City of Thornton, Colorado (Owner). This project is a part of the overall multi-phased 42-inch Thornton Water Project (TWP). This Segment of the TWP is known as Segment F.1 (Project). The Project involves the installation of the pipeline by traditional open-cut installation techniques across open land, agricultural

fields, canals, wetlands, across and within Larimer County road right-of-way, as well as the installation of the pipeline within tunnels under various paved roadways and a railroad.

1.04. LOCATION OF PROJECT SITE

- A. Segment F.1 is approximately 5.8 miles in length and originates at the Owner's future source water pump station site approximately 1.25 miles northwest of the State Highway (SH) 1 and County Road (CR) 56 intersection in Larimer County. From the source water pump station site, Segment F.1 traverses generally southeast / east across open land for about 0.5-mile where it turns south and runs parallel to Hood Lane and the Larimer County Canal for another 0.5-mile. The Segment F.1 alignment then turns southeast for approximately 0.3-mile to cross the Larimer County Canal and State Highway 1 and intersect CR 56. At CR 56, Segment F.1 turns generally east for approximately 3 miles to the BNSF railroad tracks. Along this 3-mile reach, the alignment either parallels the north or south side of CR 56 on private property or is located within the CR 56 right-of-way. At the BNSF railroad, Segment F.1 turns south and parallels the railroad tracks and high voltage overhead electric lines for 1-mile to CR 54 (Douglas Road). Prior to reaching CR 54, the alignment turns east to cross the BNSF tracks, then south to cross CR 54, and then terminates at a connection to Segment F.2. The Segment F.1 alignment is located within permanent easements obtained by the Owner or CR 56 right-of-way and crosses open land, agricultural fields, paved and gravel Larimer County Roads, State Highway 1, the Larimer County Canal, and the BNSF railroad.

1.05. OWNER AND ASSIGNED SUBCONTRACTORS

- A. Owner: City of Thornton, 9500 Civic Center Drive, Thornton, CO 80229.
- B. Engineer: Providence Infrastructure Consultants, retained to prepare Contract Documents. 300 Plaza Drive, Suite 320, Highlands Ranch, CO 80129.
- C. Owners Advisor: Jacobs Engineering has been retained as the Owners Advisor and to assist in administering agreements between the Owner, Engineer, and Contractor.
- D. Environmental Consultant: ERO Resources has been retained to perform cultural resources survey, habitat and environmental surveys, and migratory bird and raptor surveys and to provide environmental considerations and work restrictions in the Contract Documents.

- E. Construction Manager: Ditesco has been retained to as the Construction Manager to support the Owner during construction and to assist in administering agreements between the Owner, Engineer, and Contractor.

1.06. PROJECT ACCESS DURING BIDDING

- A. Bidders are encouraged to observe site conditions for the Project, but Bidders shall not access private property during the Bidding Phase. Accessing private property during the bidding phase is trespassing and will result in being disqualified from bidding. A significant portion of the Project alignment can be viewed from public rights-of-way.

1.07. OWNER-FURNISHED EQUIPMENT

- A. Owner will furnish:

- 1. Project Signs.

- a. Owner will procure and furnish up to five (5) project signs for installation by the Contractor. Project signs will be suitable for permanent installation on wooden, steel, or aluminum Unistrut frames. As construction progresses and various pipeline reaches approach substantial completion, the project signs will be removed and relocated to active portions of the project as deemed appropriate by the Construction Manager. Locations of project signs will be coordinated with and approved by the Construction Manager.
 - b. Contractor shall obtain a 'Temporary Construction and Project Marketing' Permit for the installation of project signs.

1.08. COORDINATION WITH OTHER ENTITIES

- A. There could be activities, permitting, or coordination efforts which may affect the performance and/or the schedule of the work. The Contractor is expected to proactively coordinate with a variety of entities including, but not limited to:

- 1. Private Landowners
 - 2. Water Supply & Storage Company (Larimer County Canal)
 - 3. North Poudre Irrigation Company (NPIC Canal No. 10)
 - 4. Larimer County

5. Colorado Department of Transportation
6. East Larimer County Water District (ELCO)
7. Poudre Valley Rural Electric (PVREA)
8. BNSF Railroad
9. Tri-States Power and Generation Association
10. Xcel Energy
11. State of Colorado Orphan Well Program (Inherited ownership of Prospect Energy Facilities.
12. Platte River Power Authority
13. Colorado Parks & Wildlife
14. U.S. Fish and Wildlife Service
15. Poudre Fire Authority
 - a. Contractor is required to have onsite at all times, the 2024 International Fire Code (IFC) as amended and adopted in the Larimer County Amendment/adoption documentation. Free access to the adopted codes can be found online:
 - (1) <https://www.poudre-fire.org/programs-services/community-safety-services-fire-prevention/fire-code-adoption>
 - (2) <https://codes.iccsafe.org/content/IFC2024V2.0>
 - b. Contractor to maintain proper roadway access during construction and notify fire dispatch of any road closures during construction.
16. Poudre School District
17. Larimer County Sheriff's Office

B. Contractor's use of premises:

1. Contractor shall limit all work to dedicated right-of-way and permanent and temporary easements as indicated on the Drawings.
2. Contractor can use Larimer County Road 11, 56, and 54 roadway rights-of-way for construction across and within the road right-of-way only. Storage of equipment and materials in roadway right-of-way at these locations shall be limited to construction activities and shall be removed immediately upon completion of work in the right-of-way.
3. Owner has made no provisions for additional Contractor staging and laydown areas. Contractor may make separate arrangements with adjacent or nearby landowners for acquisition of separate temporary easement in previously disturbed upland areas for Contractors use at no additional cost to Owner. Prior to securing additional area for staging, Contractor to notify the Construction Manager of the additional staging area location and duration of occupancy so that Larimer County can be notified for compliance with the Owner's 1041 permit. Additional staging areas cannot be secured without Owner and Larimer County approval. After Owner and Larimer County approval, Contractor shall provide written approval from the property owner allowing the use of their property for staging along with approved permits, as applicable.
4. Contractor shall maintain access to all roadways and all private residences for the duration of construction. Contractor shall review requirements associated with 1041 Permit Condition of Approval No. 43, and Specification 32 90 10. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual.

C. Landowner / Entity use of premises:

1. Operating facilities, private landowners, utility owners, ditch companies, and Larimer County shall have access to properties and facilities for the duration of construction. Contractor shall coordinate and cooperate with landowners to minimize construction impacts to existing operations to the extent possible.

D. Construction Water

1. Contractor shall be responsible for all construction water necessary for the work including water needed for pressure testing of the pipe.

1.09. SPARE / CONTINGENCY FITTING AND PARTS

- A. The Contractor shall furnish and store spare steel pipe fittings and pipe lengths as indicated on the Drawings. These spare parts are intended to allow either vertical or horizontal field adjustments as needed based on changed conditions. The spare steel pipe and fittings shall be furnished in the thickest pipeline wall design to allow for use on any section of pipeline and shall include filler rings as needed for use on thinner wall pipe. Spare parts may be stored at Owner Facilities, as directed by the Construction Project Manager. Spare parts shall be delivered early in the project.
- B. The Contractor shall furnish and store contingency materials and parts in the event East Larimer County Water District's 2-inch waterline is impacting during work within Larimer County Road No. 56. Contractor to refer to East Larimer County Water District Coordination Notes shown on the Contract Drawings for contingency materials and parts.

1.10. MONTHLY AERIAL PHOTOGRAPHY

- A. Refer to Section 01 32 33

1.11. SUBSURFACE UTILITY ENGINEERING

- A. Subsurface Utility Engineering (SUE) (locates and potholing) has been performed on all known utilities in accordance with ASCE 38. Where possible, all known utilities have been located, surveyed, and potholed to meet ASCE Quality Level A. Refer to the Drawings for utility pothole information.
- B. During construction, the Contractor will be responsible for providing utility locates for all Contractor installed facilities as part of this Project for the duration of construction until Initial Acceptance.
- C. Refer to Section 02 32 19 and Section 02 01 20.

1.12. WATERLINE FILLING AND HYDROSTATIC TESTING

- A. Refer to Section 33 14 00.

1.13. PRESERVATION OF TREES

- A. Related to Larimer County 1041 Permit Condition of Approval No. 78, and Specification Section 32 90 10, Contractor shall support the Construction Manager and Owner with

the preservation of trees as marked on the Contract Drawings. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual.

1.14. CONTAMINATED SOILS

- A. The Work is not anticipated to encounter contaminated soils based on field investigations and historical records reviews. However, the Work does traverse areas of existing and historical oil and gas industry exploration, storage, and distribution areas; and traverse along the BNSF; and the potential does exist to encounter unknown contaminated soils, including soils that contain hydrogen sulfide. In the event contaminated soils are encountered, the Contractor shall refer to the Materials Management Plan (MMP), included as an Attachment to the Project Manual. In addition, Contractor shall refer to the Environmental Records Review (ERR) also attached to the Project Manual. All handling and disposal requirements of contaminated soils shall comply with Federal and State regulations.
- B. The Contractor shall designate an Environmental Materials Management Coordinator (EMMC) that has sufficient knowledge and experience to identify suspected contaminated soils, groundwater, or other media within the project area, should they be encountered. The EMMC shall have the knowledge and experience with contaminated soil conditions and:
 - 1. Be accessible during all construction activities should suspicious material be encountered.
 - 2. Have sufficient training, awareness, and knowledge to identify field indications of contamination such as visual staining, discoloration, or oil sheen and able to use and interpret field equipment reading such as a Photoionization Detector (PID) used during the course of excavation to monitor for potential soil contamination.
 - 3. Have sufficient knowledge, training, and authority to coordinate the identification, confirmation, management and disposal of suspected or confirmed contaminated soils, groundwater, or other media. The presence of potentially contaminated soils shall be determined through:
 - a. Visual detection of staining, discoloration, or oil sheen.
 - b. Odor detection

c. PID monitoring device

C. If contaminated or potentially contaminated soils are identified, the Contractor shall take the necessary precautions to protect all Contractor personnel, Owner, Owners Advisor, Construction Manager, Engineer, project area and lands.

1. Contractor shall immediately notify the Construction Manager of the potential for contaminated soil.
2. Contractor shall segregate and remove potentially contaminated soil from the site for further disposition, analysis, and removal. Contractor shall replace material removed from the site with acceptable fill.
3. All contaminated soils shall be transported and disposed off-site at a certified Subtitle D landfill under a manifest in accordance with state and federal regulations. Contractor shall retain all copies of all laboratory data, profile approvals, manifests, and bills of lading for any contaminated soils encountered and removed. Owner shall approve waste disposal profile and disposal facility prior to any disposal. Potential Subtitle D landfills include:
 - a. Republic
 - b. Waste Connections
 - c. Waste Management
4. A bid item is included as a contingency for encountering contaminated soil and is described in the Measurement and Payment.

1.15. WORK RESTRICTIONS / REQUIREMENTS

A. Prior to mobilizing for construction, and during construction, Contractor shall follow the TWP Segment F.1 Outreach and Communication Plan, install Owner provided project signs, and provide information to Construction Manager on anticipated scheduled tasks that could impact the public or individual property owners. Provide information one (1) month in advance of the start of task. Information will be used for public outreach, which could include the distribution of flyers, updating the Thornton Water Project website, or letters to property owners. Thornton and the Construction Manager will coordinate distribution of information for public outreach. Contractor to refer to the requirements of Larimer County 1041 Permit Condition of Approval Nos. 23 and 42. Contractor to refer to Larimer County 1041 Permit Compliance and

Contractor Requirements Matrix and the Segment F.1 Outreach and Communication Plan which are included with the Project Manual.

B. Larimer County Roads

1. Contractor shall not use any Larimer County gravel roads other than:
 - a. Larimer County Road No. 56 between State Highway 1 and the BNSF Railroad.
 - b. Larimer County Road No. 54 between Giddings Road (LCR 9) and the easterly construction limits.
2. Should the maintenance, repair, or restoration of Larimer County Roads No. 11 or No. 13 outside of the limits of construction be required as a result of Contractor use, the Contractor shall be fully responsible for all costs and efforts associated with dust control, maintenance, repair, and restoration to the satisfaction of Larimer County.
3. Should the maintenance, repair, or restoration of Larimer County Roads No. 54 or No. 56 east of the BNSF Railroad be required as a result of Contractor use, the Contractor shall be fully responsible for all costs and efforts associated with dust control, maintenance, repair, and restoration to the satisfaction of Larimer County.

C. Operating Facility Crossings

1. Schedule and sequence work to maintain local access to all operating facilities (i.e. farming operations, utilities, irrigation ditches, businesses, etc.) and to minimize impacts to ongoing operations. Required shutdowns of access or facility operations shall be kept to a minimum. Contractor shall be responsible for providing advanced notifications prior to crossing operating facilities as required by the Contract Specifications and Drawings.

D. Major Irrigation Ditch or Canal Crossings

1. General
 - a. There shall be no construction impacts to ditches or canals during the individual ditch company's irrigation seasons.

- b. Refer to the Contract Drawings for individual ditch/canal specific construction and crossing information, requirements, and restrictions.
 - 2. Larimer County Canal (2 Crossings)
 - a. Owner: Water Supply and Storage Company
 - b. STA 66+95 and STA 199+34
 - c. See Drawings for Larimer County Canal work requirements/restrictions.
- E. Tunneled Crossings
 - 1. State Highway 1 – STA 76+34
 - a. Owner: Colorado Department of Transportation.
 - b. Work may not commence until a CDOT Utility and Special Use Permit and applicable Construction Access Permit are secured by the Contractor.
 - 2. North Giddings Road – STA 235+16
 - a. Owner: Larimer County
 - b. Work may not commence until a Right-of-Way Construction Permit has been obtained from Larimer County.
 - 3. Railroad – STA 311+71
 - a. Owner: Burlington Northern & Santa Fe Railway
 - b. The Owner has obtained a crossing license with the BNSF Railroad.
 - c. See Drawings for BNSF Railroad crossing requirements/restrictions.
- F. Migratory Bird Treaty Act (MBTA) and Bald and Golden Eagle Protection Act (BGEPA).
 - 1. Governing Authorities:
 - a. Colorado Parks & Wildlife
 - b. U.S. Fish and Wildlife Service
 - 2. See Environmental Surveys information included herein.

G. Site Preparation, Maintenance, and Restoration

1. Refer to Section 32 90 10.

H. Workdays, Hours, and Holidays

1. Workdays

- a. Construction shall be limited to Monday through Saturday. No work will be allowed on Sundays or Owner-observed holidays except in an emergency or with the prior written approval of the Construction Manager and, where required by the Larimer County 1041 Permit Conditions of Approval.

2. Hours

- a. The Contractor shall limit their working hours to: 7 a.m. to 7 p.m., Monday through Saturday.
 - b. Work between 7 p.m. and 7 a.m. on any day, and any work on Sundays or Owner-observed holidays, except in an emergency, requires the prior written approval of the Construction Manager and, where required by the Larimer County 1041 Permit Conditions of Approval. Contractor shall also abide by the work hour restrictions stipulated in the project permits.
 - c. Contractor to refer to the requirements of Larimer County 1041 Permit Condition of Approvals Nos. 20, 24, 35, and 81. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual.
 - d. Work outside of the specified hours and days shall be evaluated and approved by Larimer County Departments including Health, Planning, and Engineering. Documents supporting a deviation shall be submitted to the County a minimum of 72 hours in advance.

3. Holidays

- a. The Owner observes the following holidays, and the Contractor shall not schedule or execute work on these holidays except as provided in paragraph H.1 and H.2:

- (1) New Year's Day, January 1st.

- (2) Martin Luther King Day, 3rd Monday in January.
- (3) Presidents' Day, 3rd Monday in February.
- (4) Memorial Day, Last Monday in May.
- (5) Juneteenth, June 19th.
- (6) Independence Day, July 4th.
- (7) Labor Day, 1st Monday in September.
- (8) Veterans Day, November 11th.
- (9) Thanksgiving Day, 4th Thursday in November
- (10) Thanksgiving and Friday following Thanksgiving.
- (11) Christmas Day, December 25th.

1.16. ENVIRONMENTAL AND HABITAT SURVEYS

- A. ERO Resources performed the following field investigations and literature reviews to support project permitting; and the Contractor shall adhere to the corresponding requirements.
- B. Cultural, Historical, Archeological Resources
 - 1. There are no cultural sites or structures within the limits of construction that are listed on the State or National Register of Historic Places.
 - 2. If the Contractor identifies or suspects evidence of cultural, historical, or archeological resources during construction, the Contractor shall immediately cease all excavation and notify the Construction Manager.
 - a. Construction Manager will immediately notify the Owner, ERO Resources, the Colorado State Historic Preservation Office, and Larimer County.
 - b. Contractor may experience delays until the required due diligence is performed by ERO and the governing authorities and plans / procedures are developed for resuming construction.

- c. Work shall be discontinued until notified by the Construction Manager that work may proceed.
 - d. Compensation to the Contractor, if any, for lost time, demobilization, remobilization, or changes to construction shall be determined in accordance with changed or extra work provisions of the Contract Documents.
3. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix Conditions of Approval Nos. 11 and 74 included with the Project Manual.

C. Wetlands and Waters Surveys

- 1. ERO Resources conducted surveys identified wetlands and waters along the project and these are shown on the Drawings and listed herein. All wetlands and waters impacted will be restored to original conditions after temporary impacts.
- 2. All wetland and water crossings are considered jurisdictional by the Thornton Water Project and have U.S. Army Corps of Engineers Nationwide Permit (NWP) No. 58 requirements. The NWP is attached for Contractor use and review.
 - a. The locations where wetlands and waters that will be crossed or impacted are listed below:

Wetland / Water Stationing	Feature	ERO Wetland / Water ID(s)
38+50 – Sta 40+75	Pond	SF WETLAND 1 / SF OHWM 1
54+75	Small Drainage Swale	SF OHWM 2
66+60 – Sta 67+40	Larimer County Canal	LCC
76+93	North Poudre Irrigation Company, Canal No. 10	SF DITCH 1
80+50 – Sta 86+25	Wet Area	SF WETLAND 2
95+75 – Sta 100+95	Wet Area	SF WETLAND 3
158+00	Culvert Work on Larimer County Canal Embankment	LCC
178+00	Small Drainage Swale	SF OHWM 3

Wetland / Water Stationing	Feature	ERO Wetland / Water ID(s)
182+45	Small Drainage Swale	SF OHWM 4
199+10 – Sta 199+80	Larimer County Canal	LCC / SF WETLAND 4
206+00 – Sta 206+25	Ditch	SF DITCH 2
234+95 – Sta 235+10	Ditch	SF DITCH 3 / SF WETLAND 5

- b. For the restoration of protected wetlands and waters, Contractor to refer to the requirements of:
- (1) Specification Section 32 90 10, the Drawings, and the attached NWP No. 58.
 - (2) Larimer County 1041 Permit Conditions of Approval Nos. 10, 51 and 71. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual.

D. Habitat Surveys

1. A Habitat Assessment (HA) letter has been prepared by ERO Resources Corporation dated January 28, 2026. The HA letter presents a summary of potential habitat for federally threatened, endangered, and candidate species protected under the Endangered Species Act in the project. No habitat was identified for the federally listed species within the project area.
2. Migratory Birds and Raptors
 - a. To the extent possible, clearing of vegetation along the pipeline easement corridor should occur outside of the breeding season. Unless indicated otherwise, if vegetation is removed between March 15 and August 31 (within the primary nesting season), a nest survey will be completed within one (1) week prior to construction to confirm no active nests are within the construction limits. If active nests are found, any work that would destroy the nests would not be conducted until the birds have vacated the nests to comply with the Migratory Bird Treaty Act. Contact the Construction

Manager two (2) weeks prior to vegetation removal to schedule the nest survey during those dates.

- b. ERO Resources performed raptor surveys to identify potential nesting habitat. All located nests are being closely observed to determine the status (active/inactive; species of bird; and nesting stage (egg laying, incubating, brood rearing, or fledgling) The locations of potential raptor nesting habitat are shown below:

ID (West to East)	Species	Nest Boundary Stations	Nesting Season
1	Bald Eagle	10+00 – 48+70	12/1 – 7/31
2	Red-Tailed Hawk	25+01 – 47+02	2/1 – 8/31
3	Unknown	183+69 – 218+42	
4	Red-Tailed Hawk	208+88 – 245+17	
5	Unknown	236+79 – 274+52	

- c. The work area is within several red-tailed hawk and unknown raptor nest's 1/3-mile radius. Nest deterrents may be installed in some nest locations to discourage nesting; however, if possible complete construction in these areas outside of the breeding season between August 31 and February 1. If construction occurs in these areas during the raptor nesting season, coordinate with Construction Project Manager two (2) weeks in advance to schedule ERO Resources for supplemental surveys to determine if the nests are active prior to construction and to complete raptor monitoring as necessary.
- d. Bald eagle protective measures during the nesting season of December 1 through July 31, must follow these requirements:
- (1) If feasible , minimize the use of heavy machinery within the 1/2-mile radius bald eagle nesting boundary during the bald eagle nesting season: December 1 through July 31, or until the last fledgling has fledged and is no longer dependent on the nest, or the nest fails.
 - (2) If work is conducted within the eagle nest buffer during the nesting season, the following protocol must be conducted by ERO Resources:

- i. ERO will perform nest monitoring 3 weeks of pre-construction to confirm the nest status and determine a behavior baseline. Contractor shall provide Construction Manager with a minimum of six (6) weeks advance notice of clearing and grubbing activities.
 - ii. ERO will perform daily monitoring during the first two weeks of construction. Contractor shall provide ERO Resources with free and clear access to the construction corridor.
 - iii. ERO will perform weekly monitoring during the remainder of construction until completion of the project, young have fledged and are no longer dependent on the nest, or the nest fails.
 - iv. If adverse behavioral reactions are not observed, Thornton will coordinate with Colorado Parks and Wildlife to determine if bi-weekly or monthly monitoring may be considered. Monitoring would continue until construction has been completed, young have fledged and are no longer dependent on the nest, or the nest fails.
 - v. If adverse disturbances are observed, ERO Resources will inform the Contractor to temporarily stop work for several hours. If adverse disturbances continue to be observed, ERO and the Owner will consult Colorado Parks and Wildlife on the development and implementation of a disturbance indicator approach.
- e. No prairie dog burrows were found during the design phase of the project.
- (1) If prairie dog colonies develop during the construction phase, coordinate with the Construction Manager 4 weeks before construction to identify any work that may occur within 1/8-mile buffer of any prairie dog burrows between March 15 and October 31. If the work may take place within this buffer between these dates, a burrowing owl survey will be completed. If owls are present in the project area, activities will be restricted within 660 feet of nest burrows until the owls have migrated from the site, which will be determined through monitoring.

- (2) Contractor is responsible for prairie dog management. If prairie dog colonies develop during the construction phase, passive relocation of prairie dogs is required prior to construction and is not recommended during the birthing season, March 1 through May 31. If there are no viable passive relocation alternatives, lethal control of prairie dogs may be allowed based on consultation with ERO. Contact ERO one month prior to construction to determine the best management approach for each colony in accordance with City of Thornton prairie dog ordinance guidelines.

3. Northern Leopard Frog

- a. If feasible, schedule construction activities outside of the northern leopard frog breeding season (March 1 –May 31) along stream channels, drainage features, and wetlands along stream channels, drainage features, and wetlands within the limits of disturbance for northern leopard frogs. If a frog is encountered during construction, ERO will coordinate with CPW on actions to be taken, which may include ceasing construction in the area until the end of the breeding season (June 1). Contact the Construction Manager two (2) weeks prior to vegetation removal to schedule the surveys during the breeding season.

4. Contractor to refer to the requirements of Larimer County 1041 Permit Condition of Approvals Nos. 56, 59, and 73. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual.

1.17. PERMITS

- A. Because the Work of Segments F.1 and F.2 will be performed under one Contract, the Contractor shall not obtain duplicate permits or prepare duplicate applications, plans, or submittal packages solely because the same permit requirement appears in the Segment F.1 and Segment F.2 Technical Specifications. Where a permit requirement applies to both segments, a single permit and submittal package covering the combined Work satisfies both Specifications, unless the issuing agency requires separate segment permits. Where an issuing agency requires separate segment permits, the Contractor shall obtain them at no change in Contract Price or Contract Times. Exception: Larimer County will issue a separate Development Construction Permit (DCP) for each segment, and the Contractor shall prepare the DCP support

documentation for each segment, although supporting plans and documentation may be shared where Larimer County accepts common materials. The Contractor remains responsible for satisfying the conditions of each permit obtained.

- B. General Permitting and Alignment Permitting Matrices have been prepared and are included as an Attachment to the Project Manual. Certain permits have been acquired by the Owner. Certain permits will be the Contractor's responsibility for developing and submitting permit applications. The General Permitting and Alignment Permitting Matrices include known required permits and the party responsible. Unless otherwise noted, the party responsible will obtain and pay the associated permit fees. Costs associated with obtaining required permits shall be included in the bid price and shall be considered incidental to the relevant work items included in the bid schedule. All known permits are listed, but this does not relieve the Contractor from obtaining and paying fees associated with unknown permits. Contractor to refer to the requirements of Larimer County 1041 Permit Condition of Approvals Nos. 2 and 53. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual.
- C. Owner Obtained Permits / Clearances (Owner Responsible for Permit Fees)
 - 1. U.S. Army Corps of Engineers Nationwide Permit NWP 58
 - 2. Colorado Parks and Wildlife Migratory Bird Treaty Act Compliance
 - 3. Colorado Parks and Wildlife Bald & Golden Eagle Protection Act Compliance
 - 4. Pre-Construction Temporary Groundwater Monitoring Well Installation Permits.
 - 5. Larimer County 1041 Permit
 - 6. Larimer County Permanent Access Permits after Construction
 - 7. Permanent and Temporary Construction Easements.
 - 8. Larimer County Development Construction Permit (DCP) (Pending Approval of Contractor Required Plans and Permits)
- D. Contractor Obtained or Supported Permits / Clearances / Submittals (Contractor Responsible for Permit Fees)
 - 1. Larimer County

- a. The Larimer County 1041 Permit that Thornton obtained for the Project dictates Conditions of Approval that must be met before construction activities can begin, including contractor mobilization to the site. Larimer County will issue a DCP to the Owner after the Conditions of Approval have been met.
- b. 1041 Permit Conditions of Approval Contractor Submittals (Reference attached 1041 Compliance Matrix and Contractor Requirements and Section 32 90 10).
 - (1) These submittals will be necessary for the Owner and Contractor to finalize and secure the DCP and allow Contractor mobilization to proceed. Separate submittals shall be prepared for Segment F.1 and Segment F.2 so that Larimer County can issue separate DCP permits for each Segment. Contractor is required to be as efficient as possible developing submittals and work to minimize duplicating efforts as much as possible.
 - (2) Contractor shall immediately begin assembling the required 1041 plan submittals immediately upon Notice of Proceed (NTP) as the Owner's ability to obtain the Larimer County DCP is contingent on the review and approval of these plans. Contractor shall meet with the Owner within 7 calendar days (1 week) of NTP, and within 14 calendar days (2 weeks) of NTP with the Owner and Larimer County, to discuss the required 1041 plan submittals and the DCP process. Contractor shall submit draft copies of required plans and Contractor obtained permits (CDPHE Stormwater Permit and other permits required to work in the Larimer County right-of-way) to the Owner within 42 calendar days (6 weeks) of the initial meeting with Larimer County. Owner will review and provide Contractor comments on draft copies of plans. Contractor shall make necessary corrections and return revised plans to Owner within 14 calendar days (2 weeks) of receiving Owner comments so Owner can immediately submit required DCP application documents to Larimer County. Owner will not be responsible for project delays associated with Contractor not submitting required plans on schedule or providing plans that are poor quality and do not meet plan requirements.

- (3) Contractor shall be aware that other 1041 permit requirements need to be met that are not associated with the Plan Submittals described herein (Reference attached 1041 Compliance Matrix and Contractor Requirements).

c. Right-of-Way Construction Permit

- (1) A Right-of-Way Construction Permit will be required for work in and across Larimer County Roads 56, 11, 9 (Giddings), and 54 (Douglas).
- (2) Locations are as indicated on the Drawings.
- (3) Separate Right-of-Way permits will be required for the pipeline and fiber optic conduit installations. Contractor is advised that Owner's fiber optic cable installation contractor will access installed hand holes within Larimer County ROW for fiber optic cable installation under Contractor's fiber optic conduit permit. Contractor shall coordinate with Construction Manager to allow fiber optic cable installation under Contractor's fiber optic conduit permit when practical.

d. Access Permits

- (1) All access locations listed in the table as permanent (P) will be used for temporary construction access and will be left in place by the contractor at the completion of the project for future permanent access. All permanent access points used for temporary construction access will require a temporary access permit obtained by the contractor. All permanent access permits shall be obtained by the Owner.
- (2) All access locations listed in the table as temporary (T) will be used by the Contractor for temporary construction access only and will be removed at the completion of the project and restored to preconstruction conditions or better. All temporary construction accesses will require a temporary access permit obtained by the Contractor.
- (3) Contractor shall refer to 1041 Permit Conditions of Approval No. 46 and 65. Contractor to refer to Larimer County 1041 Permit

Compliance and Contractor Requirements Matrix included with the Project Manual.

e. Special Transport Permit

- (1) Contractor shall make sure that all material, equipment, and deliveries to the project are under Larimer County weight limit and size restrictions for the roads planned for use. If oversized / overweight loads are needed, Contractor shall obtain a Larimer County Special Transport Permit.
- (2) Contractor shall refer to 1041 Permit Condition of Approval No. 48. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual.

f. Electrical Permit

- (1) An Electrical Permit and inspection will be required for work associated with powering the cathodic protection rectifier station.

g. Temporary Construction Staging Area Requirements.

- (1) The following permits will be required from Larimer County for onsite staging areas. Permits shall be acquired prior to construction.
 - (a) Larimer County Building Permit for Temporary Construction Trailers and Offices
 - (b) Contractor shall provide the necessary information to secure the building permit.

E. Colorado Department of Transportation

1. Contractor shall obtain a Utility and Special Use Permit for the crossing of Colorado Highway 1 and for work within the Highway Right-of-Way.
2. Contractor shall obtain Construction Access Permits for Colorado Highway 1 ingress/egress as required for construction.
3. Contractor shall make sure that all material, equipment, and deliveries to the project are under Colorado Department of Transportation weight limit and size

restrictions for the roads planned for use. If oversized / overweight loads will be needed, Contractor shall obtain a CDOT Oversize/Overweight Permit.

F. Colorado Department of Public Health and Environment (CDPHE) Permits

1. Contractor shall obtain the following construction permits through the Colorado Department of Public Health and Environment (CDPHE):
 - a. CDPS General Permit, Permit Number COR-040000, Stormwater Discharge
 - b. CDPS General Permit, Permit Number COG-080000, Construction Dewatering
 - c. CDPS General Permit, Permit Number COG-604000, Hydrostatic Testing Discharge
 - d. CDPS General Permit, Permit Number APCD-223, General Air Emission Notice (APEN) and Application for Construction Permit
 - e. Asbestos Abatement Notification and Permit Application if Asbestos Cement (AC) Pipe is impacted and damaged.
2. Contractor may want to obtain separate stormwater discharge permits for the project's construction in non-agricultural areas versus agricultural areas as non-agricultural area permit can be closed quicker.
3. Contractor to submit copies of approved CDPHE permits to the Owner. The Owner shall submit the CDPHE permits to Larimer County so that the Larimer County DCP can be issued.
4. Dewatering activities shall be conducted in accordance with Permit COG-080000 and Section 31 23 19.
5. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix Conditions of Approval Nos. 2, 49, 51, 63, and 64 included with the Project Manual.

G. Colorado Division of Water Resources (DWR)

1. GWS-62: Dewatering Wells

- a. Contractor shall obtain required permits needed for installing, operating, and abandoning all dewatering wells required for construction in accordance with the requirements of the Colorado Office of the State Engineer Division of Water Resources, Section 37-91-102(6.3), C.R.S.
2. GWS-09: Well Abandonment Form:
 - a. Contractor shall abandon existing pre-construction temporary groundwater monitoring wells that were installed by the Owner. Temporary groundwater monitoring wells in accordance with the requirements of the Colorado Office of the State Engineer Division of Water Resources, Section 37-91-102(4.5), C.R.S. Well abandonment shall be performed by a licensed contractor approved by the DWR, and a Well Abandonment Report, form GWS-09, shall be filed with the DWR. Provide documentation to the Construction Manager. Wells to be abandoned by the Contractor include:
 - (1) All monitoring wells installed as part of the geotechnical investigation as defined in the Geotechnical Reports are shown on the Contract Drawings and listed in the Permitting and License Matrices. The Construction Manager will provide all geotechnical monitoring well permits to the Contractor.
 - (2) All temporary construction dewatering wells installed by the Contractor.

1.18. AGREEMENTS

- A. The Owner has obtained project agreements or provided courtesy notifications with various utilities, ditches, and authorizing jurisdictions as listed below. The Contractor will be responsible for meeting all provisions of the agreements. Contractor shall refer to the crossing requirements and restrictions shown on the Construction Drawings. Coordinate with Construction Project Manager as needed for communication with entities during construction.
 1. Xcel Energy (Gas and Electric)
 2. East Larimer County Water District
 3. Poudre Valley Rural Electric Authority (PVREA)
 4. Water Supply and Storage Company (Larimer County Canal, 2 crossings)

5. Tri-States Generation & Transmission
6. North Poudre Irrigation Company
7. Colorado Department of Natural Resources, Orphan Well Program (Prospect Energy Facilities)
8. Windsor Reservoir and Canal Company (Reservoir Outlet Pipes)
9. Platte River Power Authority
10. Private Irrigation Ditch / Lateral / Culvert at Station 135+08
11. BNSF Railway

1.19. LANDOWNER REQUIREMENTS

A. General Property Instructions / Construction Timing Restrictions for all properties:

1. Limits of Construction are shown on the Contract Drawings. No work or movement outside of these limits will be allowed.
2. Contractor to take pre-construction photos and videos to document pre-construction, construction, and post-construction photos. Refer to Specification Section 01 32 33 and Larimer County 1041 Permit Condition of Approval No. 32.
3. Owner to perform detailed vegetation and weed species inventory in native, non-cultivated areas immediately prior to site disturbance activities. Contractor shall provide Construction Manager a minimum of two (2) weeks advanced notice of any clearing and grubbing activity between March 15th and August 31st so that inventory activities can be scheduled.
4. Pre-Construction Site Preparation - Refer to Specification Section 32 90 10.
5. Site Maintenance - Refer to Specification Section 32 90 10.
6. Site Restoration - Refer to Specification Section 32 90 10.
7. Remove and reset fences that are crossed by the pipeline construction and place new access gates where shown on the Contract Drawings.
8. Contractor shall reconstruct all gravel drives/roads damaged during construction activities. – Refer to Specification Section 32 90 10.

9. Submit pre- and post-construction survey of existing topography, drainage culverts, irrigation ditches (if present), and access driveways to show that restoration was returned to pre-construction lines and grades. The pre-construction survey shall be submitted prior to construction.
10. Access to the permanent easement on the property shall be, to the maximum extent possible, through existing gates, public roads, trails, or facilities to avoid disruption to the property and adjoining properties.
11. The Owner shall provide thirty (30) days' advance notice to property owners of the commencement construction activities on each property. The Contractor shall provide the Owner the intended date to enter individual properties a minimum of 45 days prior to accessing properties to allow the Construction Manager to prepare the landowner notice.
12. Contractor shall understand the following Temporary Construction Easement (TCE) restrictions and requirements.
 - a. Contractor shall not access the Temporary Construction Easements (TCE) until 30 days after the commencement date has been provided to property owners through a formal notice of construction commencement by the Owner. The TCE will be valid for 18 months from the date of commencement provided in the formal construction commencement notice.
 - b. The Contractor shall notify the Construction Manager if additional time is needed beyond 18 months is required at least two (2) months before the TCE expires. The Owner shall negotiate the time extension with the property owner on a month-to-month basis. Any additional construction expenses associated with the time extension shall become the responsibility of the Contractor. Contractor shall reimburse Owner \$2,000 per month to cover expenses associated with the extension of TCEs.
13. If feasible, conduct construction activities on agricultural properties outside of the growing season as reasonably as possible, as the Owner will be responsible for crop damages. In addition, certain fields that use center pivot irrigation systems, will not be able to operate during construction, resulting in the Owner being responsible for crop damages for the entire planted field. Agricultural seasons should be considered April 1 through November 15.

B. Staging Areas

1. The Contractor shall have the option to set up a staging area within the construction limits shown on the contract drawings.
2. Staging areas shall have the following restrictions:
 - a. Staging areas cannot be located in wetland or riparian areas and will be limited to being placed in upland areas.
 - b. The area shall not be used for storage of non-project-related items.
 - c. The use of the construction staging areas within the permanent easement shall be limited to the time frame of the Contract. The use of construction staging areas inside the temporary construction easements are limited to 18 months from the commencement date.
 - d. The Contractor shall be responsible for preparation of the staging area and any access to the staging area from permitted access points. Access shall be constructed and maintained in accordance with the requirements of the public entity responsible for maintenance of the road.
 - e. The Contractor shall completely remove all material and equipment and restore the staging area and the temporary accesses to the pre-construction condition upon completion of the project.
 - f. The Contractor shall install silt fence and other BMPs as appropriate to prevent all silt/soil/debris from leaving the staging area.
 - g. The Contractor shall be responsible for securing the staging area to prevent access by unauthorized persons.
 - h. Obtain permits for staging area activities as required from Larimer County.

C. Tax Exempt Status

1. The Owner will provide its tax identification number for use to obtain State of Colorado sales and use tax-exempt status on “eligible” permanent materials.

D. License

1. The prime Contractor and subcontractors shall obtain and pay for all applicable

Town, County, and State licenses.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

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SECTION 01 42 13

ABBREVIATIONS AND ACRONYMS

PART 1 - GENERAL

1.01. REFERENCE TO STANDARDS AND SPECIFICATIONS OF TECHNICAL SOCIETIES

- A. Reference to standards and specifications of technical societies and reporting and resolving discrepancies associated therewith shall be as provided in Article 20 “DEFINITIONS AND TERMS” of the General Conditions, and as may otherwise be required herein and in the individual Specification sections.
- B. Work specified by reference to published standard or specification of government agency, technical association, trade association, professional society or institute, testing agency, or other organization shall meet requirements or surpass minimum standards of quality for materials and workmanship established by designated standard or specification.
- C. Where so specified, products or workmanship shall also meet or exceed additional prescriptive or performance requirements included within Contract Documents to establish a higher or more stringent standard of quality than required by referenced standard.
- D. Where two or more standards are specified to establish quality, product and workmanship shall meet or exceed requirements of most stringent.
- E. Where both a standard and a brand name are specified for a product in Contract Documents, proprietary product named shall meet or exceed requirements of specified reference standard.
- F. Copies of standards and specifications of technical societies:
 - 1. Copies of applicable referenced standards have not been bound in these Contract Documents.
 - 2. Where copies of standards are needed by Contractor, obtain a copy or copies directly from publication source and maintain in an orderly manner at the Site as Work Site records, available to Contractor’s personnel, Subcontractors, Owner, and Engineer.

1.02. ABBREVIATIONS

- A. Abbreviations for Trade Organizations and Government Agencies: Following is a list of construction industry organizations and government agencies to which references may be made in the Contract Documents, with abbreviations used.

1.	AA	Aluminum Association
2.	AABC	Associated Air Balance Council
3.	AAMA	American Architectural Manufacturers Association
4.	AASHTO	American Association of State Highway and Transportation Officials
5.	ABMA	American Bearing Manufacturers' Association
6.	ACI	American Concrete Institute
7.	AEIC	Association of Edison Illuminating Companies
8.	AGA	American Gas Association
9.	AGMA	American Gear Manufacturers' Association
10.	AI	Asphalt Institute
11.	AISC	American Institute of Steel Construction
12.	AISI	American Iron and Steel Institute
13.	AITC	American Institute of Timber Construction
14.	ALS	American Lumber Standards
15.	AMCA	Air Movement and Control Association
16.	ANSI	American National Standards Institute
17.	APA	APA – The Engineered Wood Association

18.	API	American Petroleum Institute
19.	APWA	American Public Works Association
20.	AHJ	Authority Having Jurisdiction
21.	AHRI	Air-Conditioning, Heating, and Refrigeration Institute
22.	ASA	Acoustical Society of America
23.	ASABE	American Society of Agricultural and Biological Engineers
24.	ASCE	American Society of Civil Engineers
25.	ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
26.	ASME	American Society of Mechanical Engineers
27.	ASNT	American Society for Nondestructive Testing
28.	ASSE	American Society of Sanitary Engineering
29.	ASTM	ASTM International
30.	AWI	Architectural Woodwork Institute
31.	AWPA	American Wood Preservers' Association
32.	AWPI	American Wood Preservers' Institute
33.	AWS	American Welding Society
34.	AWWA	American Water Works Association
35.	BHMA	Builders Hardware Manufacturers' Association
36.	CBM	Certified Ballast Manufacturer
37.	CDA	Copper Development Association
38.	CGA	Compressed Gas Association

39.	CISPI	Cast Iron Soil Pipe Institute
40.	CMAA	Crane Manufacturers' Association of America
41.	CRSI	Concrete Reinforcing Steel Institute
42.	CS	Commercial Standard
43.	CSA	Canadian Standards Association
44.	CSI	Construction Specifications Institute
45.	DIN	Deutsches Institut für Normung e.V.
46.	DIPRA	Ductile Iron Pipe Research Association
47.	EIA	Electronic Industries Alliance
48.	EJCDC	Engineers Joint Contract Documents' Committee
49.	ETL	Electrical Test Laboratories
50.	FAA	Federal Aviation Administration
51.	FCC	Federal Communications Commission
52.	FDA	Food and Drug Administration
53.	FEMA	Federal Emergency Management Agency
54.	FIPS	Federal Information Processing Standards
55.	FM	FM Global
56.	Fed. Spec.	Federal Specifications (FAA Specifications)
57.	FS	Federal Specifications and Standards (Technical Specifications)
58.	GA	Gypsum Association
59.	GANA	Glass Association of North America
60.	HI	Hydraulic Institute

61.	HMI	Hoist Manufacturers' Institute
62.	IBC	International Building Code
63.	ICBO	International Conference of Building Officials
64.	ICC	International Code Council
65.	ICEA	Insulated Cable Engineers' Association
66.	IFC	International Fire Code
67.	IEEE	Institute of Electrical and Electronics Engineers, Inc.
68.	IESNA	Illuminating Engineering Society of North America
69.	IFI	Industrial Fasteners Institute
70.	IGMA	Insulating Glass Manufacturer's Alliance
71.	IMC	International Mechanical Code
72.	INDA	Association of the Nonwoven Fabrics Industry
73.	IPC	International Plumbing Code
74.	ISA	International Society of Automation
75.	ISO	International Organization for Standardization
76.	ITL	Independent Testing Laboratory
77.	JIC	Joint Industry Conferences of Hydraulic Manufacturers
78.	MIA	Marble Institute of America
79.	MIL	Military Specifications
80.	MMA	Monorail Manufacturers' Association
81.	MSS	Manufacturer's Standardization Society
82.	NAAMM	National Association of Architectural Metal Manufacturers

83.	NACE	NACE International
84.	NBGQA	National Building Granite Quarries Association
85.	NEBB	National Environmental Balancing Bureau
86.	NEC	National Electrical Code
87.	NECA	National Electrical Contractor's Association
88.	NEMA	National Electrical Manufacturers' Association
89.	NESC	National Electrical Safety Code
90.	NETA	InterNational Electrical Testing Association
91.	NFPA	National Fire Protection Association
92.	NHLA	National Hardwood Lumber Association
93.	NICET	National Institute for Certification in Engineering Technologies
94.	NIST	National Institute of Standards and Technology
95.	NRCA	National Roofing Contractors Association
96.	NRTL	Nationally Recognized Testing Laboratories
97.	NSF	NSF International
98.	NSPE	National Society of Professional Engineers
99.	NTMA	National Terrazzo and Mosaic Association
100.	NWWDA	National Wood Window and Door Association
101.	OSHA	Occupational Safety and Health Act (both Federal and State)
102.	PCI	Precast/Prestressed Concrete Institute
103.	PEI	Porcelain Enamel Institute
104.	PPI	Plastic Pipe Institute

105.	PS	Product Standards Section-U.S. Department of Commerce
106.	RMA	Rubber Manufacturers' Association
107.	RUS	Rural Utilities Service
108.	SAE	SAE International
109.	SDI	Steel Deck Institute
110.	SDI	Steel Door Institute
111.	SJI	Steel Joist Institute
112.	SMACNA	Sheet Metal and Air Conditioning Contractors National Association
113.	SPI	Society of the Plastics Industry
114.	SSPC	The Society for Protective Coatings
115.	STI/SPFA	Steel Tank Institute/Steel Plate Fabricators Association
116.	SWI	Steel Window Institute
117.	TEMA	Tubular Exchanger Manufacturers' Association
118.	TCA	Tile Council of North America
119.	TIA	Telecommunications Industry Association
120.	UBC	Uniform Building Code
121.	UFC	Uniform Fire Code
122.	UL	Underwriters Laboratories Inc.
123.	UMC	Uniform Mechanical Code
124.	USBR	U.S. Bureau of Reclamation
125.	WCLIB	West Coast Lumber Inspection Bureau

126.	WI	Wood Institute
127.	WWPA	Western Wood Products Association

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

SECTION 01 42 19

REFERENCE STANDARDS

PART 1 - GENERAL

1.01. SCOPE

- A. This Section includes reference standards.

1.02. DESIGNATION OF ASSOCIATIONS, INSTITUTIONS, SOCIETIES AND STANDARDS

- A. Whenever in these Specifications reference is made to Associations, Institutions, Societies or Standards, they will be designated as follows:

1.	AASHTO	American Association of State Highway and Transportation Officials
2.	ACI	American Concrete Institute
3.	ADA	American Disability Act
4.	AGA	American Gas Association
5.	AIA	American Institute of Architects
6.	AISC	American Institute of Steel Construction
7.	AISI	American Iron and Steel Institute
8.	ANSI	American National Standards Institute
9.	API	American Petroleum Institute
10.	APWA	American Public Works Association
11.	AREA	American Railway Engineering Association
12.	ASA	American Standards Association
13.	ASCE	American Society of Civil Engineers
14.	ASME	American Society of Mechanical Engineers

15.	ASTM	American Society for Testing and Materials
16.	AWPA	American Wood Preservers Association
17.	AWS	American Welding Society
18.	AWWA	American Water Works Association
19.	BLIS	Bureau of Labor and Industries Standards
20.	BLM	Bureau of Land Management
21.	CDOT	Colorado Department of Transportation
22.	CDPHE	Colorado Department of Public Health and Environment
23.	CISPI	Cast Iron Soil Pipe Institute
24.	COE	Corps of Engineers
25.	CRSI	Concrete Reinforcing Steel Institute
26.	DEQ	Department of Environmental Quality
27.	CDPHE	Colorado Department of Public Health and the Environment
28.	EPA	Environmental Protection Agency
29.	FHWA	Federal Highway Administration
30.	FS	Federal Standards
31.	IBC	International Building Code
32.	IFC	International Fire Code
33.	IPC	International Plumbing Code
34.	IRI	Industrial Risk Insurance
35.	ISA	Instrument Society of America
36.	ISO	Insurance Service Office

37.	ITE	Institute of Traffic Engineers
38.	MHFD	Mile High Flood District
39.	MUTCD	Manual of Uniform Traffic Control Devices
40.	NBS	National Bureau of Standards
41.	NEC	National Electrical Code
42.	NESC	National Electric Safety Code
43.	NEMA	National Electrical Manufacturer's Association
44.	NFPA	National Fire Protection Association
45.	NLMA	National Lumber Manufacturer's Association
46.	OSHA	Occupational Safety and Health Administration
47.	PCA	Portland Cement Association
48.	SSPC	Steel Structures Painting Council
49.	UBC	Uniform Building Code
50.	UDFCD	Urban Drainage Flood Control District
51.	UFC	Uniform Fire Code
52.	UL	Underwriter's Laboratories, Inc.
53.	UPC	Uniform Plumbing Code
54.	USBM	United States Bureau of Mines
55.	WWPA	Western Wood Products Association

- B. Wherever specific standard numbers are indicated, e.g., ASTM C-150, it shall be understood to mean the latest revision thereof.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

SECTION 01 45 16

CONTRACTOR QUALITY CONTROL

PART 1 - GENERAL

1.01. REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. ASTM International (ASTM):
 - a. D3740, Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
 - b. E329, Use in the Evaluation of Testing and Inspection Agencies as Used in Construction.

1.02. DEFINITIONS

- A. Contractor Quality Control (CQC): The means by which Contractor ensures that the construction, to include that performed by subcontractors and suppliers, complies with the requirements of the Contract.

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Informational Submittals:
 - 1. CQC Plan: Submit, not later than 30 days after receipt of Notice to Proceed.
 - 2. CQC Report: Submit, weekly, an original and one copy in report form.
 - 3. Material test reports as requested by Larimer County and in accordance with the Right-of-Way Permit requirements.

1.04. OWNER QUALITY ASSURANCE

- A. All Work is subject to Owner's quality assurance inspection and testing at all locations and at all reasonable times before acceptance to ensure strict compliance with the terms of the Contract Documents.
- B. Thornton's quality assurance inspections and tests are for the sole benefit of Thornton and do not:

1. Relieve Contractor of responsibility for providing adequate quality control measures;
 2. Relieve Contractor of responsibility for damage to or loss of the material before acceptance;
 3. Constitute or imply acceptance; or
 4. Affect the continuing rights of Thornton after acceptance of the completed Work.
- C. The presence or absence of a quality assurance inspector does not relieve Contractor from any Contract requirement.
- D. Promptly furnish all facilities, labor, and material reasonably needed for performing such safe and convenient inspections and tests as may be required by Construction Manager.
- E. Thornton may charge Contractor for any additional cost of inspection or test when Work is not ready at the time specified by Contractor for inspection or test, or when prior rejection makes re-inspection or retest necessary. Quality assurance inspections and tests will be performed in a manner that will not unnecessarily delay the Work.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01. GENERAL

- A. Maintain an adequate inspection system and perform such inspections as will ensure that the Work conforms to the Contract Documents.
- B. Maintain complete inspection records and make them available at all times to Thornton and Construction Manager.
- C. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product that complies with the Contract Documents. The system shall cover all construction and demolition operations, both onsite and offsite, including Work by subcontractors, fabricators, suppliers and purchasing agents, and shall be keyed to the proposed construction sequence.

3.02. COORDINATION MEETING

- A. After the Preconstruction Conference, but before start of construction, and prior to acceptance of the CQC Plan, schedule a meeting with Construction Manager and Thornton to discuss the quality control system.

- B. Develop a mutual understanding of the system details, including the forms for recording the CQC operations, control activities, testing, administration of the system for both onsite and offsite Work, and the interrelationship of Contractor's management and control with the Thornton's Quality Assurance.
- C. There may be occasions when subsequent conferences may be called by either party to reconfirm mutual understandings and/or address deficiencies in the CQC system or procedures that may require corrective action by Contractor.

3.03. QUALITY CONTROL ORGANIZATION

A. CQC System Manager:

- 1. Designate an individual within Contractor's organization who will be responsible for overall management of CQC and have the authority to act in CQC matters for the Contractor.
- 2. CQC System Manager may perform other duties on the Project if approved by the Owner.
- 3. CQC System Manager shall be an experienced construction person, with a minimum of 3 years construction experience on similar type Work.
- 4. CQC System Manager shall report to the Contractor's project manager or someone higher in the organization. Project manager in this context shall mean the individual with responsibility for the overall quality and production management of the Project.
- 5. CQC System Manager shall be onsite during construction; periods of absence may not exceed 2 weeks at any one time.
- 6. Identify an alternate for CQC System Manager to serve with full authority during the System Manager's absence. The requirements for the alternate will be the same as for designated CQC System Manager.

B. CQC Staff:

- 1. Designate a CQC staff, available at the Site at all times during progress, with complete authority to take any action necessary to ensure compliance with the Contract. CQC staff members shall be subject to acceptance by Construction Manager.
- 2. CQC staff shall take direction from CQC System Manager in matters pertaining to QC.

3. CQC staff must be of sufficient size to ensure adequate QC coverage of Work phases, work shifts, and work crews involved in the construction. These personnel may perform other duties but must be fully qualified by experience and technical training to perform their assigned QC responsibilities and must be allowed sufficient time to carry out these responsibilities.
 4. The actual strength of the CQC staff may vary during any specific Work period to cover the needs of the Project. Add additional staff when necessary for a proper CQC organization.
- C. Organizational Changes: Obtain Construction Manager's acceptance before replacing any member of the CQC staff. Requests for changes shall include name, qualifications, duties, and responsibilities of the proposed replacement.

3.04. QUALITY CONTROL PHASING

- A. CQC shall include at least three phases of control to be conducted by CQC System Manager for all definable features of Work, as follows:
1. Preparatory Phase:
 - a. Notify Thornton at least 48 hours in advance of beginning any of the required action of the preparatory phase.
 - b. This phase shall include a meeting conducted by the CQC System Manager and attended by the superintendent, other CQC personnel (as applicable), and the foreman responsible for the definable feature. The CQC System Manager shall instruct applicable CQC staff as to the acceptable level of workmanship required in order to meet Contract requirements.
 - c. Document the results of the preparatory phase meeting by separate minutes prepared by the CQC System Manager and attached to the QC report.
 - d. Perform prior to beginning Work on each definable feature of Work:
 - (1) Review applicable Contract Specifications.
 - (2) Review applicable Contract Drawings.
 - (3) Verify that all materials and/or equipment have been tested, submitted, and approved.
 - (4) Verify that provisions have been made to provide required control inspection and testing.

- (5) Examine the Work area to verify that all required preliminary Work has been completed and is in compliance with the Contract.
- (6) Perform a physical examination of required materials, equipment, and sample Work to verify that they are on hand, conform to approved Shop Drawing or submitted data, and are properly stored.
- (7) Review the appropriate activity hazard analysis to verify safety requirements are met.
- (8) Review procedures for constructing the Work, including repetitive deficiencies.
- (9) Document construction tolerances and workmanship standards for that phase of the Work.
- (10) Check to verify that the plan for the Work to be performed, if so required, has been accepted by Construction Manager.

2. Initial Phase:

a. Accomplish at the beginning of a definable feature of Work:

- (1) Notify Thornton at least 48 hours in advance of beginning the initial phase.
- (2) Perform prior to beginning Work on each definable feature of Work:
 - (a) Review minutes of the preparatory meeting.
 - (b) Check preliminary Work to verify compliance with Contract requirements.
 - (c) Verify required control inspection and testing. Establish level of workmanship and verify that it meets minimum acceptable workmanship standards.
 - (d) Resolve all differences.
 - (e) Check safety to include compliance with and upgrading of the safety plan and activity hazard analysis. Review the activity analysis with each worker.
- (3) Separate minutes of this phase shall be prepared by the CQC System Manager and attached to the QC report. Exact location of initial phase

shall be indicated for future reference and comparison with follow-up phases.

- (4) The initial phase should be repeated for each new crew working onsite, or any time specified quality standards are not being met.

3. Follow-up Phase:

- a. Perform daily checks to verify continuing compliance with Contract requirements, including control testing, until completion of the particular feature of Work.
 - b. Daily checks shall be made a matter of record in the CQC documentation and shall document specific results of inspections for all features of Work for the day or shift.
 - c. Conduct final follow-up checks and correct all deficiencies prior to the start of additional features of Work that will be affected by the deficient Work. Constructing upon or concealing nonconforming Work will not be allowed.
4. Additional Preparatory and Initial Phases: Additional preparatory and initial phases may be conducted on the same definable features of Work as determined by Thornton if the quality of ongoing Work is unacceptable; or if there are changes in the applicable QC staff or in the onsite production supervision or work crew; or if work on a definable feature is resumed after a substantial period of inactivity, or if other problems develop.

3.05. CONTRACTOR QUALITY CONTROL PLAN

A. General:

1. Plan shall identify personnel, procedures, control, instructions, test, records, and forms to be used.
2. An interim plan for the first 30 days of operation will be considered.
3. Construction will be permitted to begin only after acceptance of the CQC Plan or acceptance of an interim plan applicable to the particular feature of Work to be started.
4. Work outside of the features of Work included in an accepted interim plan will not be permitted to begin until acceptance of a CQC Plan or another interim plan containing the additional features of Work to be started.

B. Content:

1. Plan shall cover the intended CQC organization for the entire Contract and shall include the following, as a minimum:
 - a. Organization: Description of the quality control organization, including a chart showing lines of authority and acknowledgment that the CQC staff will implement the three-phase control system (see Paragraph QC Phasing) for all aspects of the Work specified.
 - b. CQC Staff: The name, qualifications (in resume format), duties, responsibilities, and authorities of each person assigned a QC function.
 - c. Letters of Authority: A copy of a letter to the CQC System Manager signed by an authorized official of the firm, describing the responsibilities and delegating sufficient authorities to adequately perform the functions of the CQC System Manager, including authority to stop Work which is not in compliance with the Contract. The CQC System Manager shall issue letters of direction to all other various quality control representatives outlining duties, authorities and responsibilities. Copies of these letters will also be furnished to Thornton.
 - d. Submittals: Procedures for scheduling, reviewing, certifying, and managing submittals, including those of subcontractors, offsite fabricators, suppliers and purchasing agents.
 - e. Testing: Control, verification and acceptance testing procedures for each specific test to include the test name, frequency, specification paragraph containing the test requirements, the personnel and laboratory responsible for each type of test, and an estimate of the number of tests required.
 - f. Procedures for tracking preparatory, initial, and follow-up control phases and control, verification, and acceptance tests, including documentation.
 - g. Procedures for tracking deficiencies from identification through acceptable corrective action. These procedures will establish verification that identified deficiencies have been corrected.
 - h. Reporting procedures, including proposed reporting formats; include a copy of the CQC report form.
- C. Acceptance of Plans: Acceptance of the Contractor's basic and addendum CQC plans is required prior to the start of construction. Acceptance is conditional and will be predicated on satisfactory performance during the construction. Thornton reserves the right to require Contractor to make changes in the CQC plan and operations including removal of personnel, as necessary, to obtain the quality specified.

- D. Notification of Changes: After acceptance of the CQC plan, Contractor shall notify Construction Manager, in writing, a minimum of 7 calendar days prior to any proposed change. Proposed changes are subject to acceptance by Construction Manager.

3.06. CONTRACTOR QUALITY CONTROL REPORTING

- A. The Contractor shall use one CQC report format for all Work under the Contract. CQC reports shall:

1. Be prepared weekly and cover and account for every calendar day throughout the life of the Contract, and be signed and dated by the CQC System Manager.
2. Identify all Work, tests, inspections, deficiencies, and corrective actions by segment (F.1 or F.2) and station.
3. Contain the record content required by Section 01 45 16 (F.1) and Section 01 45 16.13 (F.2), including work performed by location and activity; control-phase activities (preparatory, initial, follow-up) with results; tests performed and results; materials received and acceptability; submittals reviewed; safety evaluations; instructions received and conflicts identified; trades and personnel counts, weather, and delays; and the Contractor's verification statement covering conforming and deficient features.
4. Be submitted through the Project's construction management software (Procore) using the format provided by the Owner's Construction Manager. The CQC System Manager shall review the current weekly report and the open-deficiency log at the weekly progress conference.

- B. The Contractor prepared CQC reports shall:

1. Maintain current records of quality control operations, activities, and tests performed, including the Work of subcontractors and suppliers.
2. Records shall be on an acceptable form and shall be a complete description of inspections, the results of inspections, daily activities, tests, and other items, including but not limited to the following:
 - a. Contractor/subcontractor and their areas of responsibility.
 - b. Operating plant/equipment with hours worked, idle, or down for repair.
 - c. Work performed today, giving location, description, and by whom. When a network schedule is used, identify each phase of Work performed each day by activity number.

- d. Test and/or control activities performed with results and references to specifications/plan requirements. The control phase should be identified (Preparatory, Initial, Follow-up). List deficiencies noted along with corrective action.
- e. Material received with statement as to its acceptability and storage.
- f. Identify submittals reviewed, with Contract reference, by whom, and action taken.
- g. Offsite surveillance activities, including actions taken.
- h. Job safety evaluations stating what was checked, results, and instructions or corrective actions.
- i. List instructions given/received and conflicts in Drawings and/or Specifications.
- j. Contractor's verification statement.
- k. Indicate a description of trades working on the Project; the number of personnel working; weather conditions encountered; and any delays encountered.
- l. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in file work and workmanship comply with the Contract.
- m. As requested by Larimer County and in accordance with the Right-of-Way Permit requirements, the Contractor will submit material test reports to Larimer County for approval and provide copies to the Construction Manager for any work in Larimer County right-of-way.

3.07. SUBMITTAL QUALITY CONTROL

- A. See Section 01 33 00. The CQC organization shall be responsible for certifying that all submittals comply with the Contract requirements. Thornton will furnish copies of test report forms upon request by Contractor. Contractor may use other forms as approved.

3.08. QUALITY CONTROL TESTING

A. Testing Procedure:

- 1. Perform tests specified or required to verify that control measures are adequate to provide a product which conforms to Contract requirements. Procure services

of a licensed testing laboratory. Perform the following activities and record the following data:

- a. Verify testing procedures comply with contract requirements.
 - b. Verify facilities and testing equipment are available and comply with testing standards.
 - c. Check test instrument calibration data against certified standards.
 - d. Verify recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.
 - e. Documentation:
 - (1) Record results of all tests taken, both passing and failing, on the CQC report for the date taken.
 - (2) Include specification paragraph reference, location where tests were taken, and the sequential control number identifying the test.
 - (3) Actual test reports may be submitted later, if approved by Engineer, with a reference to the test number and date taken.
 - (4) Provide directly to Construction Manager an information copy of tests performed by an offsite or commercial test facility. Test results shall be signed by an engineer registered in the state where the tests are performed.
 - (5) Failure to submit timely test reports, as stated, may result in nonpayment for related Work performed and disapproval of the test facility for this Contract.
2. All results and/or reports associated with compaction and material testing that takes place within Larimer County Road right-of-way must be provided to the Larimer County Engineering Department in accordance with Larimer County 1041 Permit Condition of Approval #36. Contractor to reference the 1041 Compliance Matrix and Contractor Requirements.
- B. Testing Laboratories: Laboratory facilities, including personnel and equipment, utilized for testing soils, concrete, asphalt and steel shall meet criteria detailed in ASTM D3740 and ASTM E329, and be accredited by the American Association of Laboratory Accreditation (AALA), National Institute of Standards and Technology (NIST), National Voluntary Laboratory Accreditation Program (NVLAP), the American Association of State Highway and Transportation Officials (AASHTO), or other approved national

accreditation authority. Personnel performing concrete testing shall be certified by the American Concrete Institute (ACI).

3.09. COMPLETION INSPECTION

- A. CQC System Manager shall conduct an inspection of the Work at the completion of all Work or any milestone established by a completion time stated in the Contract.
- B. Punchlist:
 - 1. CQC System Manager shall develop a punch list of items which do not conform to the Contract requirements.
 - 2. Include punch list in the CQC report, indicating the estimated date by which the deficiencies will be corrected.
 - 3. CQC System Manager or staff shall make a second inspection to ascertain that all deficiencies have been corrected and so notify the Thornton.
 - 4. These inspections and any deficiency corrections required will be accomplished within the time stated for completion of the entire Work or any particular increment thereof if the Project is divided into increments by separate completion dates.

END OF SECTION

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SECTION 01 55 26

TRAFFIC CONTROL

PART 1 - GENERAL

1.01. REFERENCES

- A. The following is a list of standards which may be referenced in this section:
1. AASHTO Roadside Design Guide, Current Edition.
 2. Manual on Uniform Traffic Control Devices (MUTCD), Current Edition.
 3. Federal Highway Administration. Standard Highway Signs.
 4. ATSSA: American Traffic Safety Services Association. Quality Standards for Work Zone Traffic Control Devices.
 5. NCHRP – Report 350 Recommended Procedures for the Safety Performance Evaluation of Highway Features.
 6. Colorado Department of Transportation (CDOT), Standard Specifications for Road and Bridge Construction (Standard Specifications), latest revision, and current standard special provisions.
 7. Colorado Department of Transportation (CDOT) Standard Plans, M & S Standards and current revisions.
 8. Larimer County Engineering and Construction Criteria, latest revision.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Administrative Submittals: Copies of permits, licenses, and approvals for construction as required by Laws and Regulations and governing agencies.
- C. Shop Drawings:
1. Approved Traffic Control and Routing Plans: As specified herein.

2. Message Boards: Proposed locations for placement at each detour or road closure, if closures are used.
3. Traffic Control Supervisor(s) Qualifications: Qualifications of proposed traffic control supervisor(s) and traffic control plan signatory.

1.03. TRAFFIC CONTROL SUPERVISOR

- A. The traffic control supervisor shall be responsible for initiating, installing, and maintaining all traffic control devices as shown on the approved Traffic Control and Routing Plans, and as specified in the MUTCD and these specifications, or as directed. The traffic control supervisor shall be employed by the Contractor and shall be assigned full time to the Project while work is underway on public roadways. The designated traffic control supervisor shall also be available to be contacted by the Owner 24 hours a day for the life of this contract. The persons so designated shall have at least one year of experience directly related to Work site traffic control in a supervisory capacity and shall be certified as a Work site traffic control supervisor by ATSSA. Submit the name and qualifications of this person for review 7 days in advance of the date set for the preconstruction conference.
- B. The traffic control supervisor shall be capable of being onsite within 45 minutes of notification. The traffic control supervisor shall make at least four inspections of all traffic control devices each day as follows:
 1. Before beginning work.
 2. At mid-shift.
 3. Half an hour after the end of the shift.
 4. Once during the period of nonworking hours.
- C. The traffic control supervisor shall make a daily record of traffic control activities using a form provided to and approved by the Owner. Submit completed forms the following work day.
- D. The traffic control supervisor shall oversee the security of the message boards to be implemented by the Contractor's field staff. Security measures shall be implemented daily and shall include locking the programming consoles, removing the tires, locking the tires to the message boards, chaining the message boards to a fixed item, and other measures to prevent theft.

- E. Each day the traffic control supervisor shall develop the messages for the message boards, determine the locations of the message boards, coordinate with field labor to locate the message boards, and program the message boards.
- F. The traffic control supervisor shall oversee the flagging operations. For road closures, the traffic control supervisor shall prepare informational handouts showing schedules and maps of the crew locations. The traffic control supervisor shall keep the handouts updated and furnish copies to the flaggers for distribution to drivers approaching closure barricades and drivers waiting to drive through single-lane zones. The traffic control supervisor shall manage the distribution of radios to flaggers, and oversee the proper functioning of radios.
- G. Each evening and morning, signs shall be covered and uncovered as needed to inform the public of roadway closures, detours, work zones, and other traffic information. Each evening just before crews leave, all signs not required shall be covered and all signs required shall be uncovered. Each morning before start of construction, all signs not required shall be covered and all signs required shall be uncovered. The traffic control supervisor shall oversee the covering and uncovering of signs each evening and morning.
- H. Traffic control supervisor shall oversee storage of materials and construction equipment along right-of-way, as needed to ensure compliance with the Contract Documents.
- I. Traffic control supervisor shall be responsible for verifying that property owner notifications are made in accordance with Contract requirements.

1.04. FLAGGER

- A. Flaggers must have a current flagging certificate and must present proof of the following certifications upon request by the Owner.
 - 1. Acceptable certifications.
 - 2. CDOT Contractor Certification.
 - 3. American Traffic Safety Services Association (ATSSA).

1.05. TRAFFIC CONTROL AND ROUTING PLANS

- A. Contractor shall submit and have an approved Traffic Control and Management Plan from Larimer County. Contractor shall make sure that requirements of 1041 Permit Conditions of Approval Nos. 43, 44, 45, 47, and 48 are met. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual. All road closures must be approved by Larimer County.
- B. The Traffic Control and Routing Plans shall be prepared and/or certified as to conformance with these Specifications by a Professional Traffic Operation Engineer (PTOE) or an ATSSA certified Work Site Traffic Control Supervisor and shall include the PTOE registration number or ATSSA certification number of the certifying person.
- C. Submit the initial phase Traffic Control and Routing Plans at the preconstruction conference. Submit plans for future phases of construction a minimum of 28 days before start of that construction phase to allow review and resubmittal, if necessary, and public notification. Meet with the Owner and affected agency having jurisdiction to review each of the Traffic Control and Routing Plans for each phase of construction. Do not begin construction on any given phase before receiving written acceptance.
- D. Failure to submit the Traffic Control and Routing Plans within the specified time frames will not be justification for additional working days. Failure to adequately address comments in any required resubmittal also will not justify additional working days.
- E. Changes to this plan shall be made only by written approval of Owner. Secure approvals for necessary changes so as not to delay progress of the Work.
- F. If multiple road closures are desired simultaneously, detours must be coordinated and approved in advance by the Owner and the agency or agencies having jurisdiction. Allow a minimum of 14 days for the Owner and the agency or agencies having jurisdiction review followed by 14 days of prior notification of residents. Multiple simultaneous road closures will require additional message boards (at each end of the closure) for duration of simultaneous closures.
- G. Traffic Routing Plan: Show sequences of construction affecting the use of roadways, time required for each phase of the Work, provisions for decking over excavations and phasing of operations to provide necessary access, and plans for signing, barricading, and striping to provide passages for pedestrians, bicycles, and vehicles. Include schedule for covering traffic control signs (including detour signs) when not in use and uncovering just prior to use.

- H. Detailed Traffic Control Plans shall show the locations of traffic cones, barrier rail, construction zones, flaggers, stored pipe and materials, construction truck access, barricades, detours, signs, message boards, temporary signals, and other traffic control facilities.
- I. On a time and day agreed upon between the Contractor and Owner, meet weekly with the Owner to describe the following week's construction operations and the traffic control provisions. At each meeting, submit a detailed update of traffic control provisions and construction crew locations. This shall be submitted in hardcopy and electronic form using a Word file. The update shall contain a list of signs and the time and location for covering and uncovering signs. The update shall include the location and wording of message control boards.
- J. In accordance with Specification Sections 01 31 19 and 01 41 10 Contractor shall understand construction scheduling constraints including constraints that maybe a result of coordination with the Poudre Fire Authority, the Poudre School District, and the Larimer County Sheriff's Office.

PART 2 - PRODUCTS

2.01. CERTIFICATIONS

- A. Use devices and systems which meet NCHRP-350 Report crash test requirements as defined in the four categories by the Federal Highway Administration. Some exceptions will be acceptable as stated below.
 - 1. Category 1: Cones, tubular marker, delineators, and drums without lights must be certified by the manufacturer as meeting NCHRP-350 Report requirements.
 - 2. Category 2: Portable sign stands with signs, Type I, II and III barricades, vertical panels, Category 1 devices with light attachments and devices not expected to cause significant vehicle velocity change. These devices and systems must be certified by FHWA as meeting NCHRP-350 Report test requirements.
 - 3. Category 3: Portable/Temporary pre-cast concrete barrier manufactured after October 1, 2002 must be certified as meeting NCHRP-350 Report test requirements:
 - a. Manufactured date to be stamped into top of each barrier section using a numeric format (ex: 10/2002) with 2 inch x 2 inch numerals, 1/4 inch deep.

- b. Portable/Temporary pre-cast concrete barrier manufactured prior to October 1, 2002 and meeting NCHRP 230 may be used until they are no longer serviceable.
- 4. Category 4: Advanced Warning Arrow Panels and portable variable message signs do not have to meet NCHRP-350 Report test requirements.

2.02. FLAGGER EQUIPMENT AND CLOTHING

- A. Comply with CDOT "Flagger Training Handbook."
- B. Comply with approved Traffic Control Drawings.
- C. Paddle: Use a combination "STOP" and "SLOW" sign paddles, a minimum of 18 inches wide, with 6-inch series "C" letters, and a rigid fixed handle approximately 5 feet in length from the bottom of the paddle to ground level. Fabricate the combination sign paddle from sheet metal or other light semi-rigid material. The background of the "STOP" face shall be red with white letters and border. The background of the "SLOW" face shall be orange with black letters and border. Use Type II reflective sheeting for the background, letters, and border on the faces of the Stop/Slow paddles.
- D. Clothing:
 - 1. Flagger vest and hard hat: Orange, red-orange, or fluorescent version of these colors:
 - a. Safety vest with a minimum of 775 inches of background material. Night work requires a minimum of 200 inches of reflective material (100 inches on the front and 100 inches on the back). Reflective material will be white and/or strong yellow-green.
 - b. Hard hat with 10 inches of white or strong yellow-green reflective tape placed around the base of the hard hat and visible to traffic from all directions.

2.03. TRAFFIC CONTROL SIGNING AND STRIPING AND DEVICES

- A. Signs:
 - 1. Comply with this Section, Article CERTIFICATIONS.
 - 2. Comply with CDOT Standard Specifications, Section 630.02, Signs and Barricades.

3. Comply with approved Traffic Control Plans.

B. Channelizing Devices:

1. Comply with Article CERTIFICATIONS.
2. Comply with approved Traffic Control Drawings.
 - a. Use construction orange tubular markers and cones during daylight hours only.

C. Barricades:

1. Comply with Article CERTIFICATIONS.
2. Comply with approved Traffic Control and Routing Plans.
3. Do not use rocks, asphalt, or concrete pieces, construction materials, and other debris as weighting devices for barricades. Sand bags will be permitted as long as a low center of gravity is maintained as approved.

D. Precast Concrete Barrier:

1. Comply with Article CERTIFICATIONS.
2. Comply with approved Traffic Control and Routing Plans.

E. Temporary Signal

1. Comply with CDOT Standard Specifications, section 630.04, Temporary Traffic Signals.

2.04. ADVANCE WARNING ARROW PANEL

A. Advance Warning Device:

1. Meet all standards as specified in the MUTCD, Section 6F.53 Arrow Panels.
2. Perform all functions as specified in contract traffic control plan sheets and the MUTCD.

PART 3 - EXECUTION

3.01. LIMITATIONS OF OPERATIONS

- A. A maximum of 8 percent vertical profile grade shall be constructed and maintained at all times in order to accommodate public traffic.
- B. Conduct traffic control in accordance with the approved Traffic Control and Routing Plans and the MUTCD.
- C. Allow emergency vehicles immediate passage.
- D. Minimum lane width shall be 9 feet, unless noted otherwise. Where cones are used to separate traffic lane from construction zone, do not use traffic lane for accessing construction zone, and do not store materials or equipment on or near shoulder of traffic lane side of roadway.
- E. Whenever it is necessary to cross, close, or obstruct driveways and walks, whether public or private, provide and maintain suitable and safe bridges, detours, or other temporary expedients for accommodation of public and private travel.
- F. Driveway and Private Road Closures: Not allowed unless approved by the Owner, Construction Manager, and property owner. If approved maintain satisfactory means of exit for persons residing or having occasion to transact business along the route of the Work. When access to private driveways must be temporarily denied due to construction operations, notify the property owner or responsible party of such closure not less than 24 hours in advance of closure. Give notification in writing and include the estimated duration of the closure.
- G. Maintain one lane of traffic at all times. Ensure access for traffic in both directions unless altering, as shown in the plans.
- H. Notify the fire department, police/sheriff department, highway patrol, ambulance service, local school district, and transit one (1) month before closing roadway or portion thereof. Notify said departments or agencies when streets are again passable for vehicles. Conduct operations with the least interference to fire equipment access, and at no time prevent such access. Furnish Contractor's night emergency telephone numbers to the police or sheriff's department.
- I. If Work will interfere with mail delivery, move mailboxes to temporary locations accessible to postal service, and on completion of Work in each area, replace them in

their original location and in a condition equal to or better than original. When access to private driveways must be temporarily denied due to construction operations, notify the property owner or responsible party of such closure not less than 24 hours in advance of closure. Give notification in writing and include the estimated duration of the closure.

- J. If Work will interfere with garbage pickup, move property owner's (resident's) garbage cans to areas accessible for garbage pickup. Garbage cans shall be returned to owner's driveway after pickup.
- K. Pedestrian, bicycle, and equestrian access along sidewalks and streets will be kept open and safe from construction activities.
- L. Coordination: Coordinate traffic routing with that of others working in the same or adjacent areas. Coordinate access for garbage pickup, mail delivery, and school buses.
- M. Each evening prior to crew departure, all Work areas shall be swept to ensure all construction debris (including, but not limited to, AC waste, gravel, and dirt) has been removed from the surface of the road. Debris shall be disposed of offsite and shall not be swept into ditches or otherwise outside of the Work area.
- N. Barricades and Lights:
 - 1. Provide as shown on the approved Traffic Control Plans and in sufficient quantity to safeguard public and Work.
 - 2. Provide as necessary to prevent unauthorized entry to construction areas and affected roads, streets, and alleyways, inside and outside of fenced area, and as required to ensure public safety and the safety of Contractor's employees, other employer's employees, and others who may be affected by the Work.
 - 3. Provide to protect existing facilities and adjacent properties from potential damage.
 - 4. Locate to enable access by facility operators and property owners.
 - 5. Protect streets, roads, highways, and other public thoroughfares that are closed to traffic by effective barricades with acceptable warning signs.
- O. Signs and Equipment:

1. Traffic control signs and equipment shall be as described herein, the MUTCD and the Standard Highway Signs, shown on Traffic Control Details, and as directed by Owner.
2. Contractor shall maintain existing traffic control signs during construction.
3. Traffic Cones: Provide as needed to delineate traffic lanes to guide and separate traffic movements. Provide at obstructions, such as material piles and equipment, as directed by Owner.
4. Illuminate barricades and obstructions with warning lights from sunset to sunrise, or as directed by Owner.
5. Use to alert general public of construction hazards, which would include surface irregularities, un-ramped walkways, grade changes, and trenches or excavations in roadways and in other public access areas.
6. Post-mount informational signs both sides of detour 14 days before detouring any traffic as to the date, time, and duration of the detour. Sign shall be stenciled with 6-inch black letters on an orange background.
7. Detour signs shall be covered when not in use and uncovered just prior to use. Detour signs shall be covered with wood or metal. The use of easily displaced material such as plastic bags, burlap sacks, duct tape, etc. is not acceptable.
8. Each sign or piece of equipment shall be certified by the manufacturer to meet the requirements of this Specification. Any sign or equipment which is damaged, or appears to be in poor condition, must be re-certified by the manufacturer. The Owner shall be the sole judge as to whether used signs or equipment supplied under this Contract need re-certification.

END OF SECTION

SECTION 01 61 00

COMMON PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.01. DEFINITIONS

A. Products:

1. New items for incorporation in the Work, whether purchased by Contractor or Owner for the Project, or taken from previously purchased stock, and may also include existing materials or components required for reuse.
2. Includes the terms material, equipment, machinery, components, subsystem, system, hardware, software, and terms of similar intent and is not intended to change meaning of such other terms used in Contract Documents, as those terms are self-explanatory and have well recognized meanings in construction industry.
3. Items identified by manufacturer's product name, including make or model designation, indicated in manufacturer's published product literature, that is current as of the date of the Contract Documents.

1.02. DESIGN REQUIREMENTS

- A. Where Contractor design is specified, design of installation, systems, equipment, and components, including supports and anchorage, shall be in accordance with provisions of latest edition of International Building Code (IBC) by International Code Council.

1.03. ENVIRONMENTAL REQUIREMENTS

- A. Altitude: Provide materials and equipment suitable for installation and operation under rated conditions at approximately 5,000 feet above sea level.
- B. Provide equipment and devices installed outdoors or in unheated enclosures capable of continuous operation within an ambient temperature range of 15°F to 100°F.

1.04. PREPARATION FOR SHIPMENT

- A. When practical, factory assemble products. Mark or tag separate parts and assemblies to facilitate field assembly. Cover machined and unpainted parts that may be damaged by the elements with strippable protective coating.
- B. Package products to facilitate handling and protect from damage during shipping, handling, and storage. Mark or tag outside of each package or crate to indicate its purchase order number, bill of lading number, contents by name, name of Project and Contractor, equipment number, and approximate weight. Include complete packing list and bill of materials with each shipment.
- C. Extra Materials, Special Tools, Test Equipment, and Expendables:
 - 1. Furnish as required by individual specifications.
 - 2. Schedule:
 - a. Ensure that shipment and delivery occurs concurrent with shipment of associated equipment.
 - b. Transfer to Owner shall occur immediately subsequent to Contractor's acceptance of equipment from Supplier.
 - 3. Packaging and Shipment:
 - a. Package and ship extra materials and special tools to avoid damage during long-term storage in original cartons insofar as possible, or in appropriately sized, hinged- cover, wood, plastic, or metal box.
 - b. Prominently displayed on each package, the following:
 - (1) Manufacturer's part nomenclature and number, consistent with Operation and Maintenance Manual identification system.
 - (2) Applicable equipment description.
 - (3) Quantity of parts in package.
 - (4) Equipment manufacturer.
 - 4. Deliver materials to Site.

5. Notify Owner upon arrival for transfer of materials.
6. Replace extra materials and special tools found to be damaged or otherwise inoperable at time of transfer to Owner.

1.05. DELIVERY AND INSPECTION

- A. Deliver products in accordance with accepted current Progress Schedule and coordinate to avoid conflict with the Work and conditions at Site. Deliver anchor bolts and templates sufficiently early to permit setting prior to placement of structural concrete.
- B. Deliver products in undamaged condition, in manufacturer's original container or packaging, with identifying labels intact and legible. Include on label, date of manufacture and shelf life, where applicable.
- C. Unload products in accordance with manufacturer's instructions for unloading or as specified. Record receipt of products at Site. Promptly inspect for completeness and evidence of damage during shipment.
- D. Remove damaged products from Site and expedite delivery of identical new undamaged products, and remedy incomplete or lost products to provide that specified, so as not to delay progress of the Work.

1.06. HANDLING, STORAGE, AND PROTECTION

- A. Handle and store products in accordance with manufacturer's written instructions and in a manner to prevent damage. Store in approved storage yards or sheds provided in accordance with Section 32 90 10. Provide manufacturer's recommended maintenance during storage, installation, and until products are accepted for use by Owner.
- B. Manufacturer's instructions for material requiring special handling, storage, or protection shall be provided prior to delivery of material.
- C. Arrange storage in a manner to provide easy access for inspection. Make periodic inspections of stored products to ensure that products are maintained under specified conditions, and free from damage or deterioration. Keep running account of products in storage to facilitate inspection and to estimate progress payments for products delivered, but not installed in the Work.

- D. Store electrical, instrumentation, and control products, and equipment with bearings in weather-tight structures maintained above 60 degrees F. Protect electrical, instrumentation, and control products, and insulate against moisture, water, and dust damage. Connect and operate continuously space heaters furnished in electrical equipment.
- E. Store fabricated products above ground on blocking or skids, and prevent soiling or staining. Store loose granular materials in well-drained area on solid surface to prevent mixing with foreign matter. Cover products that are subject to deterioration with impervious sheet coverings; provide adequate ventilation to avoid condensation.
- F. Store finished products that are ready for installation in dry and well-ventilated areas. Do not subject to extreme changes in temperature or humidity.
- G. After installation, provide coverings to protect products from damage because of traffic and construction operations. Remove coverings when no longer needed.
- H. Hazardous Materials: Prevent contamination of personnel, storage area, and Site. Meet requirements of product specification, codes, and manufacturer's instructions.

PART 2 - PRODUCTS

2.01. GENERAL

- A. Provide manufacturer's standard materials suitable for service conditions, unless otherwise specified in the individual specifications.
- B. Where product specifications include a named manufacturer, with or without model number, and also include performance requirements, named manufacturer's products must meet the performance specifications.
- C. Like items of products furnished and installed in the Work shall be end products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation and maintenance, spare parts and replacement, manufacturer's services, and implement same or similar process instrumentation and control functions in same or similar manner.
- D. Equipment, Components, Systems, and Subsystems: Design and manufacture with due regard for health and safety of operation, maintenance, and accessibility, durability of

parts, and shall comply with applicable OSHA, state, and local health and safety regulations.

- E. Regulatory Requirement: Coating materials shall meet federal, state, and local requirements limiting the emission of volatile organic compounds and for worker exposure.
- F. Safety Guards: Provide for all belt or chain drives, fan blades, couplings, or other moving or rotary parts. Cover rotating part on all sides. Design for easy installation and removal. Use 16-gauge or heavier; galvanized steel, aluminum coated steel, or galvanized or aluminum coated 1/2-inch mesh expanded steel. Provide galvanized steel accessories and supports, including bolts. For outdoors application, prevent entrance of rain and dripping water.
- G. Authority Having Jurisdiction (AHJ):
 - 1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
 - 2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.
- H. Equipment Finish:
 - 1. Provide manufacturer's standard finish and color, except where specific color is indicated.
 - 2. If manufacturer has no standard color, provide equipment with gray finish as approved by Owner.
- I. Special Tools and Accessories: Furnish to Owner, upon acceptance of equipment, all accessories required to place each item of equipment in full operation. These accessory items include, but are not limited to, adequate oil and grease (as required for first lubrication of equipment after field testing), light bulbs, fuses, hydrant wrenches, valve keys, handwheels, chain operators, special tools, and other spare parts as required for maintenance.

- J. Lubricant: Provide initial lubricant recommended by equipment manufacturer in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, startup, and operation until final acceptance by Owner.

2.02. FABRICATION AND MANUFACTURE

A. General:

1. Manufacture parts to U.S.A. standard sizes and gauges.
2. Two or more items of the same type shall be identical, by the same manufacturer, and interchangeable.
3. Design structural members for anticipated shock and vibratory loads.
4. Use 1/4-inch minimum thickness for steel that will be submerged, wholly or partially, during normal operation.
5. Modify standard products as necessary to meet performance specifications.

B. Lubrication System:

1. Require no more than weekly attention during continuous operation.
2. Convenient and accessible; oil drains with bronze or stainless steel valves and fill-plugs easily accessible from the normal operating area or platform. Locate drains to allow convenient collection of oil during oil changes without removing equipment from its installed position.
3. Provide constant-level oilers or oil level indicators for oil lubrication systems.
4. For grease type bearings, which are not easily accessible, provide and install stainless steel tubing; protect and extend tubing to convenient location with suitable grease fitting.

2.03. SOURCE QUALITY CONTROL

- A. Where specifications call for factory testing to be witnessed by Engineer, notify Engineer not less than 14 days prior to scheduled test date, unless otherwise specified.

- B. Calibration Instruments: Bear the seal of a reputable laboratory certifying instrument has been calibrated within the previous 12 months to a standard endorsed by the National Institute of Standards and Technology (NIST).
- C. Factory Tests: Perform in accordance with accepted test procedures and document successful completion.

PART 3 - EXECUTION

3.01. INSPECTION

- A. Inspect materials and equipment for signs of pitting, rust decay, or other deleterious effects of storage. Do not install material or equipment showing such effects. Remove damaged material or equipment from the Site and expedite delivery of identical new material or equipment. Delays to the Work resulting from material or equipment damage that necessitates procurement of new products will be considered delays within Contractor's control.

3.02. MANUFACTURER'S CERTIFICATE OF COMPLIANCE

- A. When so specified, a Manufacturer's Certificate of Compliance, a copy of which is attached to this section, shall be completed in full, signed by entity supplying the product, material, or service, and submitted prior to shipment of product or material or execution of the services.
- B. Engineer may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance.
- C. Such form shall certify proposed product, material, or service complies with that specified. Attach supporting reference data, affidavits, and certifications as appropriate.
- D. May reflect recent or previous test results on material or product, if acceptable to Engineer.

3.03. INSTALLATION

- A. Equipment Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned.
- B. No shimming between machined surfaces is allowed.

- C. Install the Work in accordance with NECA Standard of Installation, unless otherwise specified.
- D. Repaint painted surfaces that are damaged prior to equipment acceptance.
- E. Do not cut or notch any structural member or building surface without specific approval of Engineer.
- F. Handle, install, connect, clean, condition, and adjust products in accordance with manufacturer's instructions, and as may be specified. Retain a copy of manufacturers' instruction at Site, available for review at all times.

3.04. FIELD FINISHING

- A. In accordance with Section 09 90 00, Painting and Coating, and individual specification sections.

3.05. ADJUSTMENT AND CLEANING

- A. Perform required adjustments, tests, operation checks, and other startup activities.

3.06. LUBRICANTS

- A. Fill lubricant reservoirs and replace consumption during testing, startup, and operation prior to acceptance of equipment by Owner.

3.07. SUPPLEMENTS

- A. The supplement listed below, following "End of Section", is part of this specification.
 - 1. Form: Manufacturer's Certificate of Compliance.

END OF SECTION

MANUFACTURER'S CERTIFICATE OF COMPLIANCE

OWNER: _____ PRODUCT, MATERIAL, OR SERVICE
PROJECT NAME: _____ SUBMITTED: _____
PROJECT NO: _____

Comments: _____

I hereby certify that the above-referenced product, material, or service called for by the Contract for the named Project will be furnished in accordance with all applicable requirements. I further certify that the product, material, or service are of the quality specified and conform in all respects with the Contract requirements, and are in the quantity shown.

Date of Execution: _____, 20__

Manufacturer: _____

Manufacturer's Authorized Representative (*print*): _____

(Authorized Signature)

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SECTION 01 65 00

DELIVERY, STORAGE, AND HANDLING

PART 1 - GENERAL

1.01. DESCRIPTION

A. General

1. Manufacturers shall store all equipment at the Manufacturer's facility until the Owner or Contractor formally request delivery of equipment to the job site as specified in the Contract Documents. Manufacturer costs shall include all costs associated with the delivery, storage, and handling of all equipment over the entire equipment delivery window.
2. If the Owner or Contractor delay a delivery that would impact the assessment of liquidated damages, the delivery date will be the date that the equipment has been manufactured and placed into storage at the manufacturing facility or an off-site storage facility.
3. Manufacturers shall deliver all equipment specified in the Contract Documents to the job site within the schedule specified. The Contractor will be responsible for unloading and inspecting the equipment shipment at the job site at time of delivery and acceptance by Owner and Contractor.
4. Prior to acceptance of the equipment by the Contractor and Owner, Manufacturers shall inspect the equipment and provide certification that its condition has not been detrimentally affected either by storage, transportation, and initial off loading activities.
5. This Section specifies the general requirements for the delivery, handling, storage, protection, and inspection of equipment required in the construction of the Work. Specific requirements, if any, are specified in the equipment specifications.

B. Transportation And Delivery

1. Manufacturers shall be prepared to deliver equipment to the job site within the calendar days listed in the Contract schedule. Manufacturers shall deliver the

equipment to the job site within 10 calendar days after being formally notified by the Contractor, as long as the required delivery days are on or before the days listed in the Contract schedule. As specified in paragraph C of this Section, Manufacturers shall safely store equipment at the manufacturing plant until the equipment is shipped to the job site. Manufacturers shall be responsible for scheduling and coordinating all equipment deliveries to the job site with the Contractor, who may require varying rates of shipment to accommodate the Contractor's sequence of construction and on-site storage space constraints. Manufacturers shall formally notify the Contractor, a minimum of 10 calendar days in advance of all shipments to the job site.

2. Manufacturers shall also perform an inspection of the equipment as it arrives at the job site and provide written certification to the Contractor that the condition of the equipment has not been detrimentally affected as a result of storage, transportation, and off-loading operations. Manufacturers shall also inspect the shipment with the Contractor to assure that the equipment complies with the shipping manifest (i.e., shipped equipment and quantities are correct and items are undamaged). Manufacturers shall immediately notify the Contractor verbally and in writing of any problems.
3. Manufacturers shall advise the Contractor in writing through the submittal process specified in Section 01 33 00 of any items that are hazardous, flammable, easily damaged, or sensitive to deterioration. Prior to equipment delivery, Manufacturers shall submit material safety data sheets (MSDSs) to the Contractor for all hazardous materials/chemicals (e.g., lubricants, oils, solvents, etc.) scheduled to be delivered to the job site.
4. Manufacturers shall deliver all equipment to the site with written instructions for handling, storing, unpacking, protecting, transporting, and installing.

C. Storage And Protection

1. Manufacturers may be required to store and protect all equipment and products at an off-site storage facility for up to 90 days after the time specified in Contract schedule until the Contractor requests delivery.
 - a. Manufacturers shall store and protect equipment and products in accordance with the Manufacturer's instructions, with seals and labels intact and legible. Storage instructions will be reviewed with the Contractor. Instructions shall be carefully followed, and a written record of

this shall be kept by the Contractor. Manufacturers shall arrange storage to permit access for inspection.

- b. Manufacturers shall store all materials in a position to prevent accumulations of standing water and to prohibit rusting.
- 2. Manufacturers shall notify the Contractor in writing through the submittal process specified in Section 01 33 00 if Manufacturer's equipment and products have more stringent storage and protection requirements than specified above.
- 3. Prior to the installation of the equipment, Manufacturers shall inspect the equipment and determine that its condition has not been detrimentally affected by storage and handling by the Contractor. If such a determination reveals damage, the equipment will be judged to be defective, and it will be removed and replaced at the Contractor's expense.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

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SECTION 01 75 00

CHECKOUT AND START-UP PROCEDURES

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes administrative and procedure requirements for checkout and startup of equipment, systems, and facilities.
- B. Refer to the General Conditions for procedures related to Initial and Final Acceptance.

1.02. SCOPE

- A. Contractor shall check out, start up, and place equipment and systems into successful operation, in accordance with the material and equipment manufacturers' written instructions, suppliers' recommendations, and the Contract Documents.
- B. The Contractor shall provide the following:
 - 1. All labor, tools, materials, and equipment required to complete equipment and system checkout and startup.
 - 2. Chemicals, lubricants, and other required operating fluids necessary for checkout, startup, and initial operation of the Work.
 - 3. Any temporary or consumable items necessary for checkout, startup, and initial operation of the Work.
 - 4. Any fuel, electricity, water, and other temporary utilities and temporary facilities necessary for checkout and startup of equipment and systems, unless otherwise specified.
- C. Related Sections include but are not necessarily limited to:
 - 1. General Conditions
 - 2. Section 01 77 00 – Contract Closeout.
 - 3. Section 01 78 23 - Operation and Maintenance Data

1.03. ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. The Contractor shall coordinate checkout and startup services with Owner, the Construction Manager, and other contractors.
 2. Subject to the constraints of this Section, Owner will furnish sufficient personnel to assist Contractor in starting up equipment and system(s), but responsibility for proper operation of the Work is Contractor's.
 3. The Contractor shall not start up equipment and system(s), without submitting acceptable operations and maintenance manuals in accordance with the Contract Documents.
- B. Checkout and Startup Planning Meeting:
1. Contractor and appropriate Subcontractors and Suppliers, shall attend and participate in a meeting with Owner, Construction Manager, and Engineer to discuss planning, scheduling, and coordination of checkout and startup activities.
- C. Sequencing:
1. Contractor shall coordinate with the Owner and Construction Manager about the staging or phasing of the Work and allowable shutdowns and tie-ins.
- D. Scheduling:
1. Progress Schedule:
 - a. Contractor shall clearly indicate in the Progress Schedule planned and actual dates for checkout, startup, and field quality control activities, including all demonstration testing activities. Separately indicate checkout, startup, and field quality control activities for each equipment item and system.
 - b. Contractor shall perform startup and field quality control activities on the scheduled dates, unless otherwise acceptable to Owner, Construction Manager, and Engineer.
 2. Restrictions for Scheduling:
 - a. Startup, including initial operation of equipment and systems, shall be performed on days and times acceptable to the Owner, Construction Manager, and Engineer.
 - b. The Contractor shall provide the Owner, Construction Manager, and Engineer a minimum seven days' notice of rescheduled checkout and startup activities when the services cannot be performed as originally scheduled.

3. Operation and Maintenance Data:

- a. Refer to Section 01 78 23, Operation and Maintenance Data.

1.04. SUBMITTALS

- A. Progress Schedules indicating dates for checkout, startup, and field quality control activities.
- B. Completed checkout and startup log required of this Specifications section.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01. CHECKOUT AND STARTUP

- A. Complete manufacturers required checks for proper installation, including I/O and communication checks, before startup.
- B. Prepare the Work so it will operate properly and safely and be ready to demonstrate functional integrity during the startup.
- C. Perform startup to extent possible without introducing flow.
- D. Procedures include but are not necessarily limited to the following:
- E. Test or check and correct deficiencies of:
1. Power and monitoring circuits for continuity prior to connection to power source.
 2. Voltage of all circuits.
 3. Valve orientation and position status for manual operating mode.
 4. Instrumentation signal generation, transmission, reception, and response.
 5. Tagging and identification systems.
 6. Proper connections, alignment, calibration and adjustment.
- F. Checkout and Startup Log:

1. Prepare a log showing each equipment item and system requiring checkout and startup. Indicate in the log activities to be accomplished during checkout and startup.
2. Provide a place for recording the date and person performing required checkout and startup. Indicate associated date(s), personnel, and employer of each.
3. Submit completed checkout and startup log and obtain Owner, Construction Manager, and Engineer acceptance.

END OF SECTION

SECTION 01 77 00

CONTRACT CLOSEOUT

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This Section includes general requirements near the end of Contract time in preparation for Final Acceptance, Final Payment, normal termination of Contract, and similar actions evidencing completion of the Work.
- B. Refer to the General Conditions for procedures related to Initial and Final Acceptance.

1.02. REQUIREMENTS FOR FINAL PAYMENT

- A. Unless otherwise required elsewhere by these Contract Documents, the following shall be furnished to the Owner by the Contractor prior to application for final payment:
 - 1. Field Services including Checkout and Startup. Refer to Section 01 75 00.
 - 2. Installation instructions and Operation and Maintenance manuals, where applicable.
 - 3. Warranties/Guarantees.
 - 4. Certifications of compliance.
 - 5. Record Document submittals. Refer to Section 01 78 39.
 - 6. Other documents as may be required by the Contract Documents.
 - 7. Training as may be required by the Contract Documents.
 - 8. Spare parts and tools as may be required by the Contract Documents.
 - 9. Copies of permit closeouts.
- B. All requirements described in this Section must be completed prior to final application for payment being submitted.

1.03. PROJECT RECORD DOCUMENTS

- A. Refer to Section 01 78 39.

1.04. RELEASES FROM AGREEMENTS

- A. Furnish the Owner with written releases from property owners or public agencies where side agreements or special easements were made, or where Contractor's operations were not kept within the Construction Limits identified on the Drawings.
- B. In the event Contractor is unable to secure written releases:
 - 1. Inform Owner of the reasons.
 - 2. Owner or its representatives will examine the Site, and Owner will direct Contractor to complete the Work that may be necessary to satisfy terms of the side agreement or special easement.
 - 3. Should Contractor refuse to perform this Work, Owner reserves right to have it done by separate contract and deduct cost of same from Contract Price or require Contractor to furnish a satisfactory bond in a sum to cover legal Claims for damages.
 - 4. When Owner is satisfied that the Work has been completed in agreement with Contract Documents and terms of side agreement or special easement, right is reserved to waive requirement for written release if:
 - a. Contractor's failure to obtain such statement is due to grantor's refusal to sign, and this refusal is not based upon any legitimate Claims that Contractor has failed to fulfill terms of side agreement or special easement; or
 - b. Contractor is unable to contact or has had undue hardship in contacting grantor.

1.05. WARRANTIES AND BONDS

- A. Provide warranties for all equipment specified in the Contract Documents.
- B. The Manufacturers' warranty periods shall be per the General Conditions and the individual Specification Sections.

1.06. SUBSTANTIAL COMPLETION, INITIAL ACCEPTANCE, AND FINAL ACCEPTANCE

- A. Refer to the General Conditions for definitions and procedures.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

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SECTION 01 78 23

OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Detailed information for the preparation, submission, and Owner, Construction Manager, and Engineer review of Operations and Maintenance (O&M) Data, as required by individual Specification sections.

1.02. DEFINITIONS

- A. Preliminary Data: Initial and subsequent submissions for Owner, Construction Manager, and Engineer's review.
- B. Final Data: Owner-, Construction Manager- and Engineer-accepted data, submitted as specified herein.

1.03. SEQUENCING AND SCHEDULING

A. Equipment and System Data:

1. Preliminary Data:

- a. Do not submit until Shop Drawing for equipment or system has been reviewed and approved by the Owner or Engineer.
- b. Submit prior to shipment date.

- 2. Final Data: Submit Compilation Formatted and Electronic Media Formatted data prior to Substantial Completion of Project.

B. Materials and Finishes Data:

- 1. Preliminary Data: Submit at least 15 days prior to request for final inspection.
- 2. Final Data: Submit within 10 days after final inspection.

1.04. DATA FORMAT

A. Prepare preliminary and final data in the form of an instructional manual, in Portable Document Format (PDF).

1. Cover: Identify manual with typed or printed title “OPERATION AND MAINTENANCE DATA” and list:

- a. Project title.
- b. Designate applicable system, equipment, material, or finish.
- c. Identity of separate structure as applicable.
- d. Identify volume number if more than one volume.

2. Title Page:

- a. Contractor name, address, and telephone number.
- b. Subcontractor, Supplier, installer, or maintenance contractor’s name, address, and telephone number, as appropriate.
 - (1) Identify area of responsibility of each.
 - (2) Provide name and telephone number of local source of supply for parts and replacement.

3. Table of Contents:

- a. Neatly typewritten and arranged in systematic order with consecutive page numbers.
- b. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.

4. Text: Manufacturer’s printed data, or neatly typewritten.

1.05. SUBMITTALS

A. Make submittals in accordance with the General Conditions and Section 01 33 00.

B. Submit Operation and Maintenance Manual PDF.

1.06. DATA FOR EQUIPMENT AND SYSTEMS

A. Content For Each Unit (or Common Units) and System:

1. Product Data:

- a. Include only those sheets that are pertinent to specific product.
- b. Clearly annotate each sheet to:
 - (1) Identify specific product or part installed.
 - (2) Identify data applicable to installation.
 - (3) Delete references to inapplicable information.
- c. Function, normal operating characteristics, and limiting conditions.
- d. Performance curves, engineering data, nameplate data, and tests.
- e. Complete nomenclature and commercial number of replaceable parts.
- f. Original manufacturer's parts list, illustrations, detailed assembly drawings showing each part with part numbers and sequentially numbered parts list, and diagrams required for maintenance.
- g. Spare parts ordering instructions.
- h. Where applicable, identify installed spares and other provisions for future work (for example, reserved panel space, unused components, wiring, terminals).

2. As-installed, color-coded piping diagrams.

3. Charts of valve tag numbers, with the location and function of each valve.

4. Drawings: Supplement product data with Drawings as necessary to clearly illustrate:

- a. Relations of component parts of equipment and systems.
- b. Control and flow diagrams.

- c. Coordinate drawings with Project record documents to assure correct illustration of completed installation.
- 5. Instructions and Procedures: Within text, as required to supplement product data.
 - a. Format:
 - (1) Organize in consistent format under separate heading for each different procedure.
 - (2) Provide logical sequence of instructions for each procedure.
 - (3) Provide information sheet for Owner's personnel, including:
 - (a) Proper procedures in event of failure.
 - (b) Instances that might affect validity of guarantee or Bond.
 - b. Installation Instructions: Including alignment, adjusting, calibrating, and checking.
 - c. Operating Procedures:
 - (1) Startup, break-in, routine, and normal operating instructions.
 - (2) Test procedures and results of factory tests where required.
 - (3) Regulation, control, stopping, and emergency instructions.
 - (4) Description of operation sequence by control manufacturer.
 - (5) Shutdown instructions for both short and extended duration.
 - (6) Summer and winter operating instructions, as applicable.
 - (7) Safety precautions.
 - (8) Special operating instructions.
 - d. Maintenance and Overhaul Procedures:
 - (1) Routine maintenance.

(2) Guide to troubleshooting.

(3) Disassembly, removal, repair, reinstallation, and re-assembly.

6. Guarantee, Bond, and Service Agreement in accordance with Section 01 77 00.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

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SECTION 01 78 39
RECORD DOCUMENTS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section describes the requirements related to maintaining and submitting record documents.
- B. The Contractor shall maintain and submit one record-document set for the Work, organized and indexed by segment (F.1 or F.2), drawing sheet, and station, including record drawings, record specifications, and record shop drawings. One submission, review, and acceptance process applies to the complete set: the Contractor shall submit record documents through the Construction Manager to the Engineer of Record for each segment; the Engineer will review the record documents for its segment; and the Construction Manager will administer one final acceptance of the complete record set. Where a permit or Specification Section requires earlier delivery of specific record documents (for example, the WSSC crossing records under F.1 Section 01 78 39), those deliveries remain due as specified and are incorporated into the record set. Acceptance of the complete record set is a prerequisite to final payment as provided in the Contract Documents.

1.02. DOCUMENTS

- A. Maintain one set of the following at the Contractor's on-site facility:
 - 1. Documents and samples called for in the Contract Documents.
 - 2. Field test records.
 - 3. Certificates of compliance.
 - 4. Redlined Construction Drawings.
 - 5. Specifications.
 - 6. Addenda, Requests for Information (RFIs), Engineering Supplemental Information (ESIs), Change Orders, Amendments, and other modifications to the Contract.
 - 7. Reviewed Shop Drawings/Product Data.

1.03. MAINTENANCE OF DOCUMENTS AND SAMPLES

- A. Store documents in project site and apart from documents used for construction.

1. Provide files and racks for storage of documents.
 2. Provide storage space for samples.
- B. File documents and samples in accordance with the specifications section numbers.
- C. Maintain documents and samples in a clean, dry, legible condition and in good order. Do not use record documents for construction purposes.
- D. Documents shall be accessible to Owner or Construction Manager during normal working hours.

1.04. RECORDING

- A. Label each document "PROJECT RECORD" in neat, large printed letters with red ink or red pencil. Ink shall not be water based or subject to easy smearing.
- B. Any scanned images for the records shall be in full color.
- C. Record information concurrently with construction progress.
- D. Do not cover Work until required information is recorded.
- E. Record Drawings:
1. Where submittals are used for mark-up, record a cross-reference at corresponding location on Drawings.
 2. Field changes of dimensions, elevations, and details, as requested by the Engineer.
 3. Changes made by Addenda, Change Orders, or other modifications. Reference the related Addenda, Change Order, etc. numbers where applicable.
 4. Details not on original Contract Drawings.
 5. Horizontal and vertical locations of underground utilities and appurtenances, referenced to a minimum of two permanent surface improvements.
 6. Depths and elevations of various elements of foundation and inverts in relation to Project datum.
 7. Location of internal utilities and appurtenances concealed in the construction, referenced of visible and accessible features of the structure.
 8. All measurements must be as-built and made by a registered surveyor in the State of Colorado.

9. All drawings must be submitted to, and accepted by, the Owner or Construction Manager prior to issuing Final Acceptance.

F. Record Specifications and Addenda.

1. Legibly mark each Section to record:
 - a. Manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually furnished, particularly optional and substitute items.
 - b. Changes made by Addenda, Change Order, Amendment, or other modifications.
 - c. Related submittals, RFIs, and/or ESIs.

G. Record Product Data:

1. Maintain one copy of each product data submittal and mark-up significant variations in actual work in comparison with submitted information.
 - a. Include both variations in product as delivered to delivery destination and variations from manufacturer's instructions and recommendations for installation.
 - b. Give particular attention to concealed products and portions of the Work that cannot otherwise be readily observed. Note related Change Orders and mark-up of record drawings and specifications.
 - c. Miscellaneous Record Submittals:
 - (1) Refer to other Sections of these Specifications for requirements of miscellaneous record keeping and submittals in connection with actual performance of the Work.
 - d. Instruction Books and Operating Manuals:
 - (1) Refer to Section 01 78 23.

1.05. RECORD DOCUMENT QUALITY

- A. Record documents shall be high quality and accurate to allow certification by the project's Engineer of Record.
- B. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix Conditions of Approval Nos. 54 and 56 included with the Project Manual.

- C. DELIVERY OF SUBMITTAL
- D. Accompany submittal to the Construction Manager with transmittal letter in duplicate containing:
 - 1. Date, Project Title, and Project Number.
 - 2. Contractor's name, address, and telephone number.
 - 3. Index containing title and number of each Record Document.
 - 4. Signature of Contractor and Contractor's authorized representative.
- E. Once the crossing of Water Supply and Storage Company (WSSC) facilities are complete at Stations 67+00 (Canal) 128+30 (Outlet Pipe), 129+39 (Outlet Pipe), 156+70 (Outlet Pipe), and 199+35 (Canal), Contractor to provide record document to the Construction Manager no later than 21 days after completion of the crossings.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

(NOT USED)

END OF SECTION

SECTION 02 01 20

PROTECTION OF EXISTING UTILITIES

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials and procedures for protecting existing underground utilities. Contractor may encounter unknown private utilities including, but not limited to, waterlines, gas lines, septic lines, irrigation lines, drain tiles, water wells, and tanks.
- B. Contractor to refer to the requirements of Larimer County 1041 Permit Conditions of Approval Nos. 27, 28, 29, 38, 76, and 77. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual.

PART 2 - MATERIALS

2.01. REPLACEMENT IN KIND

- A. Except as indicated below or as specifically authorized by the Owner, Engineer, or utility owner, reconstruct utilities with new material of the same size, type, and quality as that removed.

PART 3 - EXECUTION

3.01. GENERAL

- A. Where utilities are parallel to or cross the construction but do not conflict with the permanent work to be constructed, follow the procedures given below and as indicated in the drawings. Notify utility owners in advance of the crossing construction and coordinate the construction schedule with the utility owner's requirements as required in the Contract Drawings. For utility crossings not shown in the Contract Drawings, refer to the General Conditions and the instructions of the Construction Manager for guidance.
- B. Determine the true location and depth of utilities and service connections which may be affected by or affect the work. Determine the type, material, and condition of these

utilities. To provide sufficient lead time to resolve unforeseen conflicts, order materials, and take appropriate measures to ensure that there is no delay in work.

- C. Expose utilities a minimum of ½ mile in advance of construction. Contractor shall notify the Construction Manager immediately of any utility conflicts with the pipeline design.

3.02. PROCEDURES

- A. Protect in Place: Protect utilities in place, unless abandoned, and maintain the utility in service, unless otherwise specified in the drawings or in the specifications.
- B. Cut and Plug Ends: Cut abandoned utility lines and plug the ends. Plug storm drains and sewers with a grout plug. Cap waterlines with a cast-iron cap or install a 3-foot-long concrete plug. Dispose of the cut pipe as unsuitable material.
- C. Remove and Reconstruct: Where so indicated in the drawings or as required by the Engineer, remove the utility and, after passage, reconstruct it with new materials. Provide temporary service for the disconnected utility.

3.03. COMPACTION

- A. Utilities Protected in Place: Backfill and compact under and around the utility so that no voids are left.
- B. Utilities Reconstructed: Prior to replacement of the utility, backfill the trench and compact to an elevation one foot above the top of the ends of the utility. Excavate a cross trench of the proper width for the utility and lay, backfill, and compact.
- C. Construction, Sand-Cement Slurry: If allowed by the utility owner, provide sand-cement consisting of one sack (94 pounds) of Portland cement per cubic yard of sand and sufficient moisture for workability as a substitute for other backfill materials to aid in reducing compaction difficulties. Submit specific methods and procedures for the review by the Construction Manager prior to construction.

3.04. SPECIAL CONSTRUCTION

- A. Steel I-Beam: Where indicated in the drawings or as determined by the Construction Manager, support utilities by a steel I-beam as shown on the utility support details in the drawings. The primary purpose of the beam is to prevent settlement of the utility line after construction. The Contractor is responsible for the protection of the utility during construction and shall incorporate the beam as part of the protection.

END OF SECTION

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SECTION 02 01 30

CONNECTIONS TO EXISTING BURIED PIPELINES

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This Section includes materials and installation of connections to existing Thornton Water Project buried pipeline segments.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit a detailed connection plan for each connection to existing buried pipelines. The connection plan shall include discussion on the connection sequencing and the removal method for existing bulkheads.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

3.01. CONNECTION PLAN

- A. Prior to any new connection, a written Construction Plan shall be submitted to the Engineer 14 calendar days prior to the connection for approval.
- B. After receipt of the proposed Construction Plan for the connection, if necessary, the Engineer will convene a meeting with the Engineer, Owner, and Contractor.
- C. After the meeting, the Engineer will return the proposed Construction Plan submittal with any changes noted for the Contractor to address. The Contractor shall make the corrections to the submittal and return to the Engineer for approval.
- D. Approval of the Sequence of Construction Plan must allow the Owner at least one-week notice, so that proper personnel and/or equipment can be prepared for the connection, if required.

3.02. CONNECTIONS TO EXISTING PIPELINES

- A. Excavate the points of connection prior to submittal of shop drawings to verify the location (i.e., northing, easting, and elevation) information provided on the Construction Drawings.
- B. Verify outside diameters prior to ordering materials.
- C. Notify the Engineer immediately of any discrepancies between the existing field conditions and the Construction Drawings.
- D. Make connections with a buttstrap joint:
 - 1. Install the buttstrap in accordance with the details on the Construction Drawings and Section 33 11 11. Remove exterior coating on the existing pipe prior to installing the buttstrap.
 - 2. After installing the buttstrap, finish the external joint using a heat shrink sleeve in accordance with Section 09 97 18.
 - 3. After the external work is complete, finish the internal joint grouting in accordance with the details on the Construction Drawings.

END OF SECTION

SECTION 02 32 19

SUBSURFACE UTILITY LOCATING (POTHOLING)

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials and procedures for performing pothole operations to locate existing underground utilities.
- B. Contractor to refer to the requirements of Larimer County 1041 Permit Conditions of Approval Nos. 27, 28, 29, and 77. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix included with the Project Manual.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit the following at least seven (7) calendar days prior to the commencement of field activities.
 - 1. Right-of-Way permits including traffic control/protection plan.
 - 2. Proposed method of potholing, including description of equipment to be used and schedule for potholing. Obtain Owner and Engineer's approval of pothole locations prior to commencement of field activities.
 - 3. Temporary steel cap and/or steel plate bridging shop drawings.
 - 4. Sand-cement slurry mix design.
 - 5. Asphalt concrete mix design.
- C. Submit field logs to the Owner within two working days after the completion of pothole excavations in each area. Include dates of potholing operations and any additional discovered information or pertinent data. Include for each pothole excavation field log:
 - 1. Pothole number.
 - 2. Date of pothole.
 - 3. Depths to top and bottom of utility (measured from existing grade over utility at pothole).

4. Miscellaneous Contractor's notes.

1.03. PROCEDURES

- A. Subsurface utility-locating (potholing) services shall conform to CI/ASCE 38-02. For the purpose of this scope, "locate" means to obtain the horizontal and vertical position of the utility line by excavating a circular test hole or narrow. Construct test holes using vacuum excavation or comparable nondestructive equipment in a manner that will cause no damage to the utility.
- B. Subsurface utility locating shall consist of test hole excavations at locations indicated on the pothole plans. Narrow trench excavations (slot potholes) may be required at locations approved by the Owner or to locate multiple parallel utilities.

1.04. STANDARD SPECIFICATIONS

- A. Wherever reference is made to the CDOT Specifications such reference shall mean the State of Colorado Department of Transportation Standard Specifications, latest edition.
- B. Wherever reference is made in this section to the LCRARS, such reference shall be understood to mean the "Larimer County Rural Area Road Standard", latest edition.
- C. Wherever reference is made in this section to the ROWCP, such reference shall be understood to mean the provisions provided in the Larimer County Right-of-Way Construction Permit.

PART 2 - MATERIALS

2.01. SAND-CEMENT SLURRY FOR BACKFILL

- A. For use backfilling test holes and exploratory trenches.
- B. Sand-cement slurry backfill shall consist of two sacks of Type I or II Portland cement added per cubic yard of imported sand and sufficient water for workability.

2.02. ASPHALT CONCRETE FOR PAVEMENT REPAIR

- A. All asphalt concrete pavement repair at exploratory trenches and at test holes within the Larimer County right-of-way shall be repaired in accordance with the LCRARS the ROWCP provisions.
- B. All other asphalt concrete pavement repair at exploratory trenches and at test holes shall be as follows:

1. Patch material shall be a high-performance asphalt cold patch material for repairing potholes and cracks greater than 1-inch wide in asphalt pavements. Material shall conform to ASTM International D448 Standard Classification for Sizes of Aggregate for Road and Bridge Construction, such as Quikrete Commercial Grade Permanent Blacktop Repair #1701, or approved equal.
2. Paving thickness shall match existing plus 1-inch.

2.03. GRAVEL FOR ROADWAY REPAIR

- A. All gravel roadway repair at exploratory trenches and at test holes within the Larimer County right-of-way shall be repaired in accordance with the ROWCP provisions.
- B. All other gravel roadway repair at exploratory trenches and at test holes shall be completed filled with CDOT Specification Class 5 or Class 6 and compacted.

PART 3 - EXECUTION

3.01. POTHOLING OPERATIONS

- A. Backfill and repair test hole excavations immediately after obtaining the measurement data. Backfill and repair trench excavations requiring use of temporary steel plate bridging within four working days. Promptly provide notice to the Owner for scheduling field survey activities. Advise Owner of number of pothole excavations completed and number remaining.
- B. Utility Notification Center of Colorado (UNCC) Requirements: Comply with UNCC requirements for notification prior to excavation. Contact UNCC by dialing 811 or www.call811.com no less than two and no more than ten days prior to the start of exploratory excavation. Verify whether or not a representative of each utility or agency will be present during excavation, and coordinate with said individual(s). Take any precautions required by the utility owner.
- C. Conduct potholing operations in a manner that minimizes the damage potential to existing underground utilities in order to ensure that the existing facilities will remain in operation without interruption.
- D. Pothole excavations shall sufficiently expose subsurface utilities to allow surveyor to easily determine and measure the following data:
 1. Elevation at top and bottom of utility.
 2. Elevation of existing grade over utility at pothole.
 3. Coordinates at surface.

4. Outside diameter of utility or width of duct banks.
 5. Utility material and condition.
- E. Location and Depiction of Existing Utilities: Pothole maps for subsurface utility locating shall be present and utilized during potholing activities. The plans shall be compared to utility/agency paint markings following UNCC notification as well as locations pre-marked by the Owner's surveyor. If discrepancies are found between the plans and paint markings, promptly notify the Owner prior to commencement of any excavation
 - F. Traffic Control
 - G. Furnish, install, maintain, and remove necessary traffic signs, barricades, lights, signals, cones, pavement markings, and other traffic control devices. Traffic control shall be performed in accordance with OSHA Regulations for Construction Projects.
- 3.02. EXCAVATION
- A. Protect utilities or underground structures from damage during potholing. Any damaged utilities shall be immediately reported to the affected utility's owner and the Owner. Repair immediately any damaged utilities in accordance with the respective utility owner's requirements. Neatly cut and remove existing pavement. Excavate test holes in such a manner as to prevent any damage to wrappings, coatings, or other protective coverings, utilizing vacuum excavation or hand digging.
 - B. Methods: Backhoe excavation is not permitted. The following methods shall be utilized for pothole excavations:
 1. Hand Digging: Hand digging is the method of excavating a pothole by manual means with hand-held, non-mechanical equipment such as a shovel.
 2. Vacuum Excavation: Vacuum excavation shall consist of air or water pressure to break up the soil and a vacuum device to collect the spoil. Determine if air or water vacuum excavation shall be used depending upon specific site and environmental characteristics. Soil type such as heavy clay may require water vacuum excavation. Utilize air vacuum excavators if mud from water vacuum excavators cannot be disposed properly. Use air vacuum excavators if damage to utilities, such as cutting through cables, will occur with the use of water vacuum excavators.
 - a. Air: Air vacuum excavators shall utilize a high velocity air stream to penetrate, expand, and break up the soil. Remove the loosened particles of soil and rock from the excavation through the use of a vacuum.

- b. Water: Water vacuum excavation systems shall excavate the pothole using high-pressure water to reduce and loosen the soil. Remove the wet soil and mud slurry to a spoil tank using a vacuum.
 - C. Size of Test Hole Excavation: Maximum test hole size shall be 8-inches in diameter at surface, unless indicated otherwise by Owner.
 - D. Size of Exploratory Trench Excavation: Trench width and length shall be as approved by the Owner. Trench depth shall be as required to accurately locate subsurface utilities.
- 3.03. TEMPORARY STEEL PLATE BRIDGING
- A. Where required, provide steel plate bridging with a nonskid surface and shoring to preserve unobstructed traffic flow. In such cases, the following conditions shall apply:
 - 1. Steel plates used for bridging shall extend a minimum of 12-inches beyond the edges of the trench.
 - 2. Install steel plate bridging to operate with minimum noise.
 - 3. Shore the trench to support the bridging and traffic loads.
 - 4. Use temporary paving with cold asphalt concrete to feather the edges of the plates if plate installation by Method 2 is used.
 - 5. Secure bridging against displacement by using adjustable cleats, shims, or other devices.
 - B. Install steel plate bridging and shoring using the following method:
 - 1. Attach approach plate(s) and ending plate (if longitudinal placement) to the roadway by a minimum of two dowels predrilled into the corners of the plate and drilled 2-inches into the pavement. Butt subsequent plates to each other. Compact fine graded asphalt concrete to form ramps, maximum slope 8.5% with a minimum 12-inch taper to cover all edges of the steel plates. When steel plates are removed, backfill the dowel holes in the pavement with either graded fines of asphalt concrete mix or concrete slurry.
 - C. Maintain the steel plates, shoring, and asphalt concrete ramps.
 - D. Unless specified, use of steel plate bridging at any given location shall not exceed four consecutive working days in any given week. Cover backfilling of excavation with a minimum of 3-inches of temporary layer of cold mix asphalt concrete.
 - E. The following table shows the required minimal thickness of steel plate bridging required for a given trench width:

Trench Width (feet)	Minimum Plate Thickness (inches)
1	1/2
1-1/2	3/4

- F. The Contractor may use standard steel plate with known coefficient of friction equal or exceeding 0.35.
- G. Use a “Rough Road” sign (W8-8) with black lettering on an orange background in advanced of steel plate bridging. This is to be used along with any other required construction signing.

3.04. POTHOLE REPAIR

- A. After excavating a test hole or trench, provide and install a temporary steel cap (over test hole) or temporary steel plate bridging (over trench) to facilitate data gathering by Owner’s surveyor.
- B. Following data gathering by surveyor, remove temporary steel caps and/or steel plate bridging, and backfill excavation with approved material as follows:
 - 1. Test Hole Excavations: Sand-cement slurry backfill per Part 2 of this section. Bring to grade with asphalt cement pavement per Part 2 of this section. Match existing pavement thickness plus 1-inch.
 - 2. Exploratory Trenches: Backfill per Part 2 of this section. Match existing pavement thickness plus 1-inch.
- C. The finished surface of the repair shall be of like material and constructed to the same finished grade as the adjacent pavement. The finished surface shall be such that it does not allow water to pond. There shall be no discernable difference in surface level at the joint between the existing pavement and the completed repair.

3.05. DISPOSAL OF CUTTINGS

- A. Dispose of cuttings off-site.

END OF SECTION

SECTION 03 01 30

CONCRETE REPAIR

PART 1 - GENERAL

1.01. DESCRIPTION

- A. Provide materials labor and equipment necessary to repair concrete in coordination with the Owner and Engineer.
- B. Complete repair mortar system installation in accordance with these specifications and the mortar system manufacturer's instructions regarding surface preparation, application, curing, inspection and requirements for safety.
- C. Complete crack repair work in accordance with these specifications and crack repair material manufacturer's instructions.
- D. Complete joint repair work in accordance with these specifications and the joint repair material manufacturer's instructions.
- E. The location, extent and repair system used for areas of concrete repair shall be coordinated with the Engineer. These include but are not limited to locations where acidic attack of the concrete surfaces has reached a depth of ½" or deeper and at any air voids, bugholes or poorly consolidated concrete areas where the specified filler/surfacer materials cannot be used for filling or surfacing of the concrete.
- F. The repair work specified herein is intended to cover the requirements for repair of concrete only, to a maximum depth of approximately 2-inches. If after surface preparation and cleaning, an area is discovered that requires a repair greater than 2-inches deep, or an area is discovered that requires repair or replacement of reinforcing steel notify the Engineer so that details may be provided to the Contractor for completion of repairs in these locations. The Work and materials associated with the repair of these areas shall be at no additional cost to the Owner.

1.02. REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 503.4: Standard Specification for Repairing Concrete with Epoxy Mortars.
- B. American Society for Testing and Materials (ASTM):
 - 1. C33: Standard Specifications for Concrete Aggregates.
 - 2. C150: Standard Specification for Portland Cement.

3. C321: Standard Test Method for Bond Strength of Chemical-Resistant Mortars.
4. C882: Test Method for Bond Strength of Epoxy Resin Systems.
5. D570: Test Method for Water Absorption of Plastics.
6. D638: Test Method for Tensile Properties of Plastics.
7. D695: Test Method for Compressive Properties of Rigid Plastics.
8. D790: Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
9. D4262: L.R. Standard Test Method for pH of Chemically Cleaned or Acid Etched Concrete Surfaces.
10. E337: L.R. Standard Practice Test Method for Measuring Humidity with a Psychrometer.

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Repair drawings or photos referenced to redlined drawings showing the areas of planned repair and methods to be employed.
- C. Procedures proposed for the accomplishment of repair work. Include a detailed description of the methods and equipment to be used for each operation, and the sequence of operations to be coordinated with other works in progress.
- D. Manufacturer's recommendations and product data sheets for all repair materials including performance criteria, surface preparation, ambient condition requirements and applications, curing requirements, volatile organic compound (VOC) data, and safety requirements.
- E. Material Safety Data Sheets (MSDS) for any materials brought on-site including all repair system materials, solvents and abrasive blast media.
- F. Design Mixes: Provide concrete and cement mortar in conformance with Section 03 30 00 and as specified herein.

1.04. QUALITY ASSURANCE

- A. Furnish the names of all subcontractors proposed for use for this work including necessary evidence and/or experience records to ascertain their qualifications in the application of epoxy, polyurethane, polymer-modified and cement-based compounds.

B. Include in accepted applicator qualifications:

1. A minimum of five years' experience in applying epoxy, polyurethane and polymer-modified and cement-based compounds similar to those specified in this Section.
2. A letter from the manufacturer of the specified materials, on the manufacturer's letterhead, signed by an officer of the company, stating that the subcontractor/applicator has been trained in the proper techniques for the preparation of the surface, and proper methods for mixing, placing, curing, and caring of the manufacturer's products. This letter shall further state that the subcontractor/applicator is on the manufacturer's approved list of contractors.

C. Adhere strictly to the manufacturer's recommendations regarding temperature at time of application for all work. Do not use epoxy materials when either the temperature of the concrete to be repaired or the ambient temperature is below 50 degrees F for a period of 24 hours before, during, or for a period of 48 hours after the completion of the repair. Temporary heat may be used to meet the specified requirements.

D. Use new epoxy, repair materials and use within the shelf life limitations set forth by the manufacturer. Clearly mark the shelf life limitations of each container.

E. The Contractor is ultimately responsible for the concrete repair work. Inspections by the Owner or Construction Manager do not limit the Contractor's responsibility.

F. Make all parts of the work accessible for inspections by the Owner or Construction Manager. Correct any conditions not in conformance with the specifications at no additional cost to the Owner.

G. The Contractor shall provide a Representative on site at all times when work is ongoing to represent the Contractor and to have authority to receive and execute all instructions given by the Owner or Construction Manager.

H. Allow changes in the specified repair work methods only with the permission of the Engineer.

I. Provide technical field support or training services required by the accepted material manufacturers at no additional cost to the Owner.

J. Provide materials from a single manufacturer for all components of a single repair.

1.05. MANUFACTURERS SERVICES

A. Provide the services of a qualified manufacturer's technical representative to instruct the Contractor's personnel in the mixing, proper use and application of the epoxy, polyurethane, polymer-modified and cement-based compounds.

- B. Provide written certification from the manufacturers' representative that materials have been mixed and applied properly and surfaces to receive these products have been prepared properly, all in conformance with manufacturer's requirements.
- C. Provide on-site time required for the manufacturer's representative to achieve a successful installation at no additional cost to the Owner.

1.06. DELIVERY, STORAGE AND HANDLING

- A. Provide shelter to store materials in area or areas designated by the Owner solely for this purpose. Confine mixing, thinning, clean-up and associated operations and storage of repair mortar materials debris before authorized disposal, to these areas.
- B. Mix all specified materials in the sheltered mixing operation and materials from direct sunlight and inclement weather. Protect facilities from staining and damage.
- C. Do not dispose of waste materials on-site.
- D. Store waste temporarily in closed, nonflammable containers until final disposal. Keep no rubbish in Contractor's area longer than 24 hours.
- E. Deliver all materials to the job site in new, unopened containers. Each container shall bear the manufacturer's name and label. Labels on all material containers shall contain the following information:
 - 1. Name of product.
 - 2. Federal Specification Number if applicable.
 - 3. Manufacturer's batch number.
 - 4. Manufacturer's name.
 - 5. Generic type of material.
 - 6. Hazardous material identification label.
 - 7. Shelf life date.
- F. Clearly mark all containers indicating any safety hazards associated with the use of or exposure to the materials.
- G. Handle and store materials to prevent damage or loss of label. Protection of materials is the Contractor's responsibility.

1.07. PROJECT / SITE CONDITIONS

A. Environmental Requirements:

1. Comply with the repair material manufacturer's recommendations as to environmental conditions under which materials can be applied and cured.
2. Do not apply materials when dust is being generated.

B. Protection:

1. Cover or otherwise protect finish work or other surfaces not being repaired.

C. Ventilation:

1. Provide ventilation to meet product requirements prior to, during, and after application.

PART 2 - PRODUCTS

2.01. WATER

- A. The water used for mixing concrete repair products shall be clear, potable and free of deleterious substances.

2.02. AGGREGATE

- A. All aggregates shall conform to ASTM C33 and Section 03 30 00.

2.03. EPOXY BONDING AGENT

- A. Epoxy bonding agent shall conform to ASTM C881 Type I, II, IV or V; Grade 2 for epoxy resin adhesives, depending on the application. The class of epoxy bonding agent shall be suitable for all ambient and substrate temperatures.
- B. Products:
 1. Sika Corp.; Sikdur 32.
 2. Euclid Chemical Company; Duralcrete.
 3. Or acceptable equivalent product.

2.04. ANTI-CORROSION COATING

- A. Anti-corrosion coating shall be a three-component, epoxy-modified cementitious material.

B. Products:

1. Sika Corp.; Sika Armatec 110.
2. Sto Concrete Restoration Division; CR 246.
3. Euclid Chemical Company; Duralprep.
4. Or acceptable equivalent product.

2.05. EPOXY CRACK REPAIR BINDER

A. Epoxy crack repair binder shall be a two-component, 100 percent solids, high-modulus, low viscosity epoxy adhesive suitable for crack grouting by injection or gravity feed.

B. Products:

1. Sika Corp.; Sikadur 52.
2. Euclid Chemical Company; Duralcrete LV.
3. BASF Chemical Company; SBC Concretive 1380.
4. Or approved equal.

2.06. FLEXIBLE POLYURETHANE CRACK REPAIR MATERIAL

A. Flexible polyurethane crack repair material shall be a one-component, water-activated polyurethane hydrophilic injection grout capable of 700 percent expansion. Polyurethane grout shall form a tough flexible foam seal that is impenetrable to water.

B. Products:

1. Prime Resins; Prime Flex 900 XLV.
2. Avanti International; Scotch Seal 5600 Chemical Grout.
3. Or acceptable equivalent product.

2.07. EPOXY REPAIR MORTAR

A. Epoxy Repair Mortar shall be two-component, 100 percent solids, and 100 percent reactive epoxy resin system.

B. Spall repair mortar for use in horizontal applications.

1. Products:

- a. BASF Building Systems; Concreseive Paste LPL.
 - b. Sika Chemical Corp.; Sikadur 22 Lo-Mod.
 - c. Or acceptable equivalent product.
 - C. Spall repair mortar for use in vertical and overhead applications.
 - 1. Products:
 - a. Sika Chemical Corp.; Sikadur 23 Lo-Mod Gel.
 - b. Or acceptable equivalent product.
- 2.08. SPALL REPAIRS, NON-SHRINK CEMENTITIOUS MORTAR
- A. Products:
 - 1. BASF Building Systems; EMACO S88 CI.
 - 2. BASF Building Systems; Thorite.
 - 3. Sauereisen, Inc.; Underlayment F-120.
 - 4. Or acceptable equivalent product.
- 2.09. SPALL REPAIRS, POLYMER MODIFIED CEMENTITIOUS MORTAR
- A. Repair spalls repair not requiring formwork using a two-component, polymer-modified cementitious mortar having a minimum 28-day compressive strength of 7,000 psi.
 - B. Spall repair mortar for use in horizontal applications.
 - 1. Products:
 - a. Sika Corp.; Sikatop 122 Plus.
 - b. Euclid Chemical Company; Duraltop Fast Set.
 - c. Or acceptable equivalent product.
 - C. Spall repair mortar for use in vertical applications.
 - 1. Products:
 - a. Sika Corp; Sikatop 123 Plus.
 - b. Euclid Chemical Company; Duraltop Gel.

- c. Or acceptable equivalent product.

2.10. SPALL REPAIRS, FORMWORK

- A. Repair spalls requiring formwork using a two-component, polymer-modified cementitious mortar/pea gravel mixture and shall have a minimum 28-day compressive strength of 6,000 psi. Mix each unit of mortar with Saturated Surface Dry (SSD) pea gravel to form the repair material following the manufacturer's recommendations.
- B. Products:
 - 1. Sika Corp.; Sikatop 111 Plus.
 - 2. Euclid Chemical Company; Duraltop Flowable Mortar.
 - 3. Or acceptable equivalent product.

2.11. SEALANT

- A. Sealant shall be a two-component polyurethane sealant as specified in Section 03 15 00. Primers and bond breakers shall conform to the sealant manufacturer's recommendations.

2.12. EXPANSION JOINT FILLER

- A. Expansion joint filler shall be as specified in Section 03 15 00.

PART 3 - EXECUTION

3.01. GENERAL REQUIREMENTS

- A. Perform exterior work during dry weather and appropriate temperature conditions in accordance with the manufacturer's recommendations. Protect unfinished work during inclement weather with tarpulins or heavy gage polyethylene sheeting.
- B. Perform work in spaces within structures at temperature and conditions suitable for proper curing in accordance with the manufacturer's recommendations.
- C. Coordinate concrete rehabilitation work with other work being performed.
- D. Remove scaling, broken, loose and disintegrating materials by use of hand tools or power driven saws, down to solid unyielding material.

- E. Clean surfaces thoroughly of efflorescence, oils, grease and other objectionable material in area to be repaired in accordance with the manufacturer's recommendations.

3.02. EPOXY BONDING AGENT

- A. Use epoxy bonding agent to adhere fresh mortar to existing concrete. Roughen existing concrete surfaces prior to application of bonding agent. Concrete surface shall be clean and sound, free of all foreign particles and laitance. Place repair material while bonding agent is still tacky or per the written instructions of the manufacturer. Reapply bonding agent if bonding agent cures prior to placement of repair material.
- B. Conform to all the requirements of ACI 503.4, and as specified herein.

3.03. ANTI-CORROSION COATING

- A. Sandblast, clean and coat reinforcing steel that is cut or exposed during alteration and/or repair operations with an anti-corrosive coating.
- B. Cover all exposed parts of the steel with the coating and apply according to manufacturer's recommendations.

3.04. EPOXY CRACK REPAIR

- A. Cracks on horizontal surfaces: When permitted by the Engineer, repair existing structural cracks by gravity feeding an epoxy crack repair binder into the prepared crack.
 - 1. Rout concrete surface at the crack to form a minimum 1/4-inch wide by 1/4-inch deep V-notch and clean to remove all loose and foreign particles. Fill crack with clean, dry sand and pour epoxy crack repair binder into V-notch, completely filling crack.
 - 2. As binder penetrates into crack, apply additional binder to the V-notch.
- B. Cracks on vertical or horizontal surfaces: Repair existing structural cracks by pressure injecting an epoxy crack repair binder into the prepared crack. Seal cracked surfaces and install injection ports per manufacturer's recommendations.
 - 1. Do not cut reinforcement steel when drilling holes for injection ports. If rebar is encountered during drilling, abandon the hole and relocate. Patch the abandoned hole immediately with epoxy mortar flush with the surface of the existing concrete.
 - 2. Once the surface sealing material has cured, inject crack with epoxy crack repair binder as directed by the manufacturer.

3. Remove injection ports upon satisfactory completion of crack injection and patch with epoxy mortar.

3.05. FLEXIBLE POLYURETHANE CRACK REPAIR

- A. Repair leaking cracks by pressure injecting with a waterproof hydrophilic injection grout seal crack surfaces and install injection ports per manufacturer's recommendations.
- B. Do not cut rebar when drilling holes for injection ports. If rebar is encountered during drilling, abandon the hole and patch immediately with epoxy mortar flush with the surface of the existing concrete.
- C. Once the surface sealing material has cured, inject crack with waterproof hydrophilic injection grout as directed by the manufacturer.

3.06. SPALL REPAIR:

- A. Saw cut the perimeter of the repair area to a minimum depth of 1/2-inch below the surface of the concrete. Chip all loose concrete in the repair area to remove loose and degraded concrete to a minimum of 1/2-inch or until a sound substrate is reached. Clean the area and repair to the original dimensions with spall repair patching material according to the manufacturer's recommendations.
- B. Make final finished surface of patches flat, level and even with the existing concrete surface. Do not feather repair mortar to meet existing concrete surface.
- C. Finish final patches on horizontal surfaces consistent with the finish on the existing structure.

3.07. JOINT REPAIR

- A. Remove sealant, bond breaker and joint filler.
- B. Remove unsound concrete on the joint faces.
- C. Remove laitance and provide a clean dry surface.
- D. Prepare an epoxy mortar by combining epoxy crack repair binder with aggregate following the manufacturer's instructions.
- E. Restore surface to original dimensions by troweling epoxy mortar onto the existing substrate in a manner to ensure bonding following the manufacturer's instructions.
- F. Cure repair in accordance with the manufacturer's instructions.
- G. Install new joint filler, bond breaker and sealant.

3.08. CURING

- A. Cure repair materials in accordance with manufacturer recommendations.

3.09. CLEANING

- A. Mechanically remove excess material from walls, floors, etc. after material has cured.
- B. Clean excess materials caused by work under this Section from existing surfaces by the use of power sanders. Vacuum surfaces to receive final cleaning and finishing specified under other sections of the specifications. Sand cracks flush to adjacent surfaces.
- C. Remove misplaced sealants using methods and materials recommended by the manufacturers. Leave finished work and work area in a neat and clean condition.

3.10. CLOSEOUT ACTIVITIES

- A. Provide in accordance with Section 01 77 00.

END OF SECTION

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SECTION 03 10 00

CONCRETE FORMWORK

PART 1 - GENERAL

1.01. DESCRIPTION

- A. Provide design and furnish materials for fabricating, erecting and removing formwork, falsework and shoring for cast-in-place concrete as shown on the Contract Drawings and specified herein for a complete installation.
- B. Use formwork to cast all cast-in-place concrete structures.

1.02. REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 117/117R: Standard Tolerances for Concrete Construction and Materials.
 - 2. 309.2R: Identification and Control of Visible Effects of Consolidation on Formed Concrete Surfaces.
 - 3. 318/318R: Building Code Requirements for Structural Concrete and Commentary.
 - 4. 347: Guide to Formwork for Concrete.
- B. American Society of Civil Engineers (ASCE):
 - 1. ASCE 7, Minimum Design Loads for Buildings and other Structures – 2010 Edition
- C. Engineered Wood Association (APA).
- D. National Institute of Product Standards and Technology:
 - 1. Voluntary Product Standard PS 1 Structural Plywood.

1.03. DESIGN REQUIREMENTS

- A. Design formwork in conformance with methodology of ACI 347R for anticipated loads, lateral pressures, depth of concrete placement and rate of concrete placement. Design

shall consider any special requirements due to the use of self consolidating, plasticized and/or retarded set concrete. All forms and shoring shall be designed at the contractor's expense.

1.04. QUALIFICATIONS

- A. Formwork Designer: Formwork, falsework, and shoring design shall be by a licensed engineer.

1.05. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- A. Submit product data for form ties, spreaders, chamfer strips, form coatings, void form system and bond breakers.
- B. Submit formwork drawings and calculations signed and sealed by a professional civil engineer or structural engineer.

1.06. QUALITY ASSURANCE

- A. Design of Formwork:
 - 1. The Contractor shall assume responsibility for the design, engineering and construction of formwork. Forms shall be designed to produce concrete members identical in shape, lines and dimensions to members shown on the Contract Documents.
 - 2. When high range water reducer (superplasticizer) is used in concrete mix or when self consolidated concrete is specified, forms shall be designed for full hydrostatic pressure per ACI 347.
 - 3. The formwork shall be designed for the loads and lateral pressures in accordance with ACI 347.
 - 4. Construction and contraction joints, openings, offsets, keyways, recesses, moldings, chamfers, blocking, screeds, bulkheads, waterstops, anchorages, inserts, and other features shall be provided.
 - 5. Formwork shall be designed to be readily removable without impact, shock, or damage to 'green' concrete surfaces and adjacent materials.

6. The maximum panel deflection shall be 1/360 of the span between structural members.

- B. Unless otherwise specified herein, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits as given in ACI 117.
- C. Materials, fabrications and workmanship found defective shall be promptly removed and replaced and new acceptable work shall be provided in accordance with Contract requirements at no additional cost to the Owner.

1.07. DELIVERY, STORAGE, AND HANDLING

- A. Materials shall be delivered to the site in an undamaged condition and at such intervals as will avoid delay in the work.
- B. Material shall be stored and protected in a clean, properly drained location. Material shall be kept off the ground under a weather-tight covering permitting good air circulation. Formwork materials shall be stored on dry wood sleepers, pallets, platforms or other appropriate supports which have slope for positive drainage. Materials shall be protected from distortion, excessive stresses, corrosion and other damage. Materials shall not be stored on the structure in a manner that might cause distortion or damage to the supporting structure.

PART 2 - PRODUCTS

2.01. LUMBER

- A. Lumber used in form construction shall be Douglas fir, No. 2 grade, S4S, Standard Grading and Dressing Rules No. 16, West Coast Lumber Inspection Bureau; or Southern Yellow Pine, No. 2, S4S, Standard Grade Rules Southern Pine Inspection Bureau. Boards shall be 6 inches or more in width.

2.02. PLYWOOD

- A. Only grade-marked plywood conforming to APA shall be provided.
- B. Plywood used in form construction shall be Grade B-B, Class 1 plyform, mill-oiled, and sanded on both sides in conformance with U.S. Product Standard PS 1 Structural Plywood.

- C. Thickness shall be sized to maintain alignment and surface smoothness, but not less than 5/8-inch thick.

2.03. STEEL FORMS

- A. Commercial grade sheets not less than 16 gage shall be provided.
- B. Stock material that is free from warps, bends, kinks, cracks, and rust or other matter that could stain the concrete shall be provided.

2.04. VOID FORM SYSTEM

- A. Void Form System:
 - 1. Void form system shall consist of corrugated paper void form materials and accessories to properly create a temporary support for the placement of structural concrete. The void form composition must be of corrugated paper material with a moisture resistant exterior, and having an interior fabrication of a uniform, cellular configuration.
 - 2. Void form system must be capable of sustaining the vertical and/or lateral loads applied until the concrete above becomes self-supporting, while maintaining full void depths as indicated on the Drawings. The void form strength must be capable of sustaining an average working load for concrete heights as indicated on the drawings based on manufacturer's recommendations.
 - 3. Where supports for reinforcing steel are placed directly on void forms, protective cover sheets must be placed over void forms to distribute working load, bridge small gaps, and protect void material from puncture and other damage during concrete placement. Void forms that are exposed after concrete formwork is removed must be shielded with a HDPE backfill retainer to prevent the migration of backfill material into the voided area.

2.05. FORM MATERIAL LOCATIONS

- A. Wall Forms and Underside of Slabs and Beams:
 - 1. Materials: Plywood, hard plastic finished plywood, overlaid waterproof particleboard, or steel in new and undamaged condition, of sufficient strength and surface smoothness to produce specified finish.

- B. Forms for Structural Concrete on Top of Steel Pipe: Materials as specified for void forms.
- C. All Other Forms: Materials as specified for wall forms.

2.06. FORM TIES

- A. Locate form ties on exposed surfaces in a uniform pattern. Place form ties so they remain embedded in the concrete except for a removable portion at each end. Form ties shall have conical or spherical type inserts with a maximum diameter of 1 inch. Construct form ties so that no metal is within 1-1/2 inch of the concrete surface when the forms, inserts, and tie ends are removed. Do not use wire ties. Ties shall withstand all pressures and maintain forms within acceptable deflection limits.
- B. Flat bar ties for panel forms shall have plastic or rubber inserts having a minimum depth of 1-1/2 inch and sufficient dimensions to permit patching of the tie hole.
- C. Tapered form ties shall be tapered through-bolts or through-bolts that utilize a removable tapered sleeve.
- D. Wire ties are not permitted.
- E. Water Stop for Ties: For water-holding structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:
 - 1. Integral steel water stop 0.103 inch thick and 0.625 inch in diameter tightly and continuously welded to tie.
 - 2. Neoprene water stop 3/16-inch thick and 15/16 inch diameter whose center hole is one-half diameter of tie, or molded plastic water stop of comparable size.
- F. Elastic Vinyl Plug:
 - 1. Design and size of plug shall allow insertion with tool to enable plug to elongate and return to original length and diameter upon removal forming watertight seal.
 - 2. Manufacturer:
 - a. Dayton Superior, Miamisburg, OH; A58 Sure Plug.
 - b. Or acceptable equivalent product.

G. Mechanical EPDM Rubber Plug:

1. Mechanical plug for taper tie.
2. Manufacturers:
 - a. Greenstreak Group Inc.
 - b. Or acceptable equivalent product.
3. Friction fit plugs will not be allowed.

2.07. BOND BREAKER

- A. Bond breaker shall be a V.O.C.-compliant nonstaining type that will provide a positive bond prevention.
- B. Manufacturers:
 1. Edoco Burke; Clean Lift 90 W.B.
 2. Nox-Crete, Inc.; Silcoseal 97EC.
 3. Or acceptable equivalent product.

2.08. FORM CAULKING

- A. Form caulking shall be a one-component, gun-grade silicone sealant that is capable of producing flush, watertight and non-absorbent surfaces and joints. Sealant shall be compatible with the type of forming material and concrete ingredients used.
- B. Products:
 1. Series 1200 Construction Caulking; GE Silicones, Waterford, NY.
 2. Dow Corning 999-A; Dow Corning Co., Midland, MI.
 3. Or acceptable equivalent product.

2.09. CHAMFER STRIPS

- A. Provide chamfer strips, of the size required to form the chamfered edge detail shown on the Drawings. Chamfer strips shall be milled from clear, straight-grain pine, surfaced

each side, or having extruded vinyl type with or without nailing flange unless otherwise shown on the Contract Documents.

2.10. INSERTS

- A. Provide galvanized cast steel or galvanized welded steel inserts, complete with anchors to concrete and fittings such as bolts, wedges and straps.

2.11. FORM RELEASE AGENT

- A. Form release agent shall not bond with, stain, or adversely affect concrete surfaces and shall not impair subsequent treatments of concrete surfaces when applied to forms. A ready-to-use water-based material formulated to reduce or eliminate surface imperfections and containing no mineral oil or organic solvents.

- B. Manufacturers and Products:

- 1. BASF, Shakopee, MN; MBT, Rheofinish 211.
 - 2. Cresset Chemical Company; Crete-Lease 20-VOC.
 - 3. Unitex Chemicals; Farm Fresh.
 - 4. Magic Kote: Symons Corporation, Des Plaines, IL.
 - 5. Or acceptable equivalent product.

PART 3 - EXECUTION

3.01. FORM TOLERANCES

- A. Comply with the requirements of ACI 117 for tolerances for formed surfaces except as specified in Table 03 10 00-1.

Table 03 10 00-1	
Vertical alignment (plumbness)	1/4-inch in any 10 feet and 1-inch maximum for entire length
Variation in the lines and surfaces of foundation mats, base slabs and walls	1/4-inch in any 10 feet and 1-inch max. for entire length
Variation from the level or from the grades indicated on the Drawings	1/4-inch in any 10 feet
Variation of the linear structure lines from established position in plan	1/2-inch in any 20 feet and 1-inch maximum for entire length
Variation of distance between walls	1/4-inch in any 10 feet and 1-inch maximum for entire length and height
Variation in the sizes and locations of sleeves, floor openings and wall openings	Minus 1/4-inch. Plus 1/2-inch.
Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls	Minus 1/4-inch. Plus 1/2-inch.
Offset between adjacent panels of formwork facing material	1/2-inch (ACI 117 Class C finish).
Offset between adjacent panels of formwork facing material for exposed surfaces where appearance is of importance	1/8-inch (ACI 117 Class A finish).

- B. Tolerances are not cumulative.
- C. Where equipment is to be installed, comply with manufacturer's tolerances if more restrictive than above.
- D. Failure of the forms to produce the specified concrete surface and surface tolerance shall be grounds for rejection of the concrete work. Rejected work shall be repaired or replaced at no additional cost to the Owner.

3.02. PREPARATION

- A. Clean form surfaces to be in contact with concrete or foreign material prior to installation. Tape, gasket, plug, and/or caulk joints, gaps, and apertures in forms so that the joint will remain watertight and withstand placing pressures without bulging outward or creating surface irregularities.
- B. Coat form surfaces in contact with concrete with a form release agent prior to form installation.
- C. Keep form coatings off steel reinforcement, items to be embedded, and previously placed concrete.
- D. Steel Forms: Apply form release agent to steel forms as soon as they are cleaned to prevent discoloration of concrete from rust.

3.03. ERECTION AND INSTALLATION

- A. Forms shall be constructed in accordance with ACI 347 to required dimensions, plumb, straight and mortar tight, and all joints and seams shall be made mortar-tight. Forms shall be substantial, properly braced, and tied together to maintain position and shape and to resist all pressures to which they may be subject. Unless otherwise indicated on the Contract Documents, formwork shall be constructed so that the concrete surfaces will conform to the tolerance limits in ACI 117 and herein specified.
- B. Provide means for holding adjacent edges and ends of form panels tight and in accurate alignment to prevent the formation of ridges, fins, offsets, or similar surface defects in the finished concrete. Forms shall be tight and shall prevent the loss of mortar and fines during placing and vibration of concrete.
- C. Provide one cleanout and inspection opening 12 inches wide by 18 inches high every 7 feet at the bottom of each lift of forms.
- D. Provide exterior corners in concrete members with chamfers as specified.
- E. Provide means for removing forms without injury to the surface of finished concrete.
- F. Do not embed any form-tying device or part thereof other than metal in the concrete.
- G. Locate large end of taper tie on the "wet" side of the wall.

- H. Use only form or form-tying methods that do not cause spalling of the concrete upon form stripping or tie removal.
- I. Form surfaces of concrete members except where placement of the concrete against the ground is shown in the Drawings. The dimensions of concrete members shown in the Drawings apply to formed surfaces, except where otherwise indicated. Placement of concrete against the ground shall be limited to footings.
- J. Openings shall be of sufficient size to permit final alignment of pipes or other items without deflection or offsets of any kind. Allow space for packing where items pass through the wall to ensure watertightness. Provide openings with continuous keyways and water stops. Provide a slight flare to facilitate grouting and the escape of entrained air during grouting. Provide formed openings with additional reinforcement as shown in the typical structural details. Reinforcing shall be at least 2 inches clear from the opening surfaces and encased items.
- K. Set anchor bolts and other embedded items accurately before placing concrete and hold securely in position until the concrete is placed and set. Check special castings, channels, or other metal parts that are to be embedded in the concrete prior to and again after placing concrete. Check nailing blocks, plugs, and strips necessary for the attachment of trim, finish, and similar work prior to placing concrete.

3.04. PROTECTION

- A. During installation, the forms shall not be used as a storage platform nor as a working platform until the forms have been permanently fastened in position.

3.05. VOID FORM SYSTEM REPLACEMENT

- A. Void Form System Placement:
 - 1. Store void forms and accessories in accordance with manufacturer's recommendations.
 - 2. Assemble products as recommended by manufacturer to develop designed strengths. Install void forms and accessories in accordance with manufacturer's recommendations. Use end caps to seal exposed ends. Use seam pads to cover joints to prevent concrete intrusion. Place a layer of protective cover board over void forms as necessary to distribute working load, bridge small gaps, and protect them from puncture and other damage during concrete placement.

3. Protect void forms from moisture, and replace wet or damaged pieces before placing concrete. Immediately protect exposed void forms after concrete formwork has been stripped with an HDPE retainer to keep backfill material from migrating into the voided area. The retainer should be installed per the manufacturer's recommendations. Maintain moisture and humidity levels beneath concrete structure.

3.06. PIPES AND WALL CASTINGS CAST IN CONCRETE

- A. Install wall spools, wall flanges, and wall anchors before placing concrete. Do not weld, tie, or otherwise connect the wall castings or anchors to the reinforcing steel.
- B. Support pipe and fabricated fittings to be encased in concrete on concrete piers or pedestals. Carry concrete supports to firm foundations so that no settlement will occur during construction.
- C. Pipes or wall castings located below operating water level shall have water stop weep ring collars and shall be cast in place. Do not block out such piping and grout after the concrete section is cast unless permitted, authorized or directed by the Engineer. Pipes fitted with thrust rings shall be cast in place.

3.07. REMOVAL OF FORMS

- A. Forms shall be removed in accordance with ACI 347 recommendations without damage to concrete and in a manner to ensure complete safety to the structure. Forms, form ties and bracing shall not be removed without specific permission of the Contractor's Registered Professional Engineer.
- B. The following table indicates the minimum allowable time after the last cast concrete is placed before forms, shoring, or wall bracing may be removed; during which the air surrounding the concrete is above 50 degrees F.

Table 03 10 00-2	
Sides of footings and encasements	24 hours
Walls, vertical sides of beams, girders, columns, and similar members not supporting loads	48 hours
Slabs, beams, and girders	10 days (forms only)
Shoring for slabs, beams, and girders	Until concrete strength reaches 70 percent specified 28-day strength (based on field cylinders) and 7 days minimum
Wall bracing	Until top or roof slab concrete reaches 70 percent specified 28-day strength and 7 days minimum

- C. Removal times will be increased if the concrete temperature following placement is permitted to drop below 50 degrees F.
- D. Do not remove supports and reshore.

3.08. PATCHING OF TAPERED TIE HOLDS

- A. Elastic Vinyl Plugs:
 - B. Clear tie hole of all loose debris with a taper tie void brush and flush debris from tie hole with air or water.
 - C. Install elastic vinyl plug from larger tie hole end in accordance with manufacturer's instructions using an insertion tool as recommended by the manufacturer.
 - D. Coat entire annular surface of the hole with epoxy bonding compound prior to filling with non-shrink, non-metallic patching mortar. Apply epoxy in accordance with manufacturer's instructions.
 - E. Fill each side of hole with mortar. Apply mortar to the "wet" side of the wall first. Consolidate mortar solidly into the hole.
- F. Mechanical Plugs:

- G. Clear tie hole of all loose debris with a taper tie void brush and flush debris from tie hole with air or water.
- H. Install mechanical plug in accordance with manufactures instructions.
- I. Coat entire annular surface of the hole with epoxy bonding compound prior to filling with non-shrink, non-metallic patching mortar. Apply epoxy in accordance with manufacturer's instructions.
- J. Fill each side of hole with mortar. Apply mortar to the "wet" side of the wall first. Consolidate mortar solidly into the hole.

3.09. FIELD QUALITY CONTROL

- A. Contractor shall notify the Owner or Construction Manager of readiness for items under this Section to be inspected a minimum of five working days prior to the items being covered by further work. Failure to provide this notification will be cause for delay in placing until observations can be completed.

END OF SECTION

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SECTION 03 15 00

CONCRETE JOINTS AND ACCESSORIES

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section describes materials, testing, and installation of concrete joints and accessories as specified and as shown on the Contract Drawings.

1.02. REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. C920: Specification for Elastomeric Joint Sealants.
 - 2. C1193: Guide for Use of Joint Sealants.
 - 3. D412: Standard Test Methods of Vulcanized Rubber and Thermoplastic Elastomers – Tension.
 - 4. D570: Standard Test Method for Water Absorption of Plastics.
 - 5. D624: Standard Test method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers.
 - 6. D638: Standard Test Method for Tensile Properties of Plastics.
 - 7. D746: Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
 - 8. D747: Standard Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam.
 - 9. D792: Standard Test Methods for Density and Specific Gravity of Plastics by Displacement.
 - 10. D994: Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).

11. D1171: Standard Test Method for Rubber Deterioration – Surface Ozone Cracking Outdoors or Chamber (Triangular Specimens).

12. D2240: Standard Test Method for Rubber Property – Durometer Hardness.

B. Environmental Protection Agency (EPA):

1. 40 CFR 59: National Volatile Organic Compound Emission Standards for Consumer and Commercial Products.

C. Corps of Engineers:

1. CRD-C 572: Specifications for Polyvinylchloride Waterstop.

D. Federal Specifications:

1. TT-S-00230C: Sealing Compound: Elastomeric Type, Single Component.

1.03. SUBMITTALS

A. Make submittals in accordance with the General Conditions and Section 01 33 00.

B. Submit manufacturer's printed data and application instructions for specified materials and locations where materials are to be used.

C. Submit one sample of each type of waterstop.

D. Submit layouts for joints.

E. Submit Certification that materials used within the joint system are compatible with each other.

1.04. QUALITY ASSURANCE

A. Do not add, relocate or omit joints without written permission from the Engineer.

B. Reject material exceeding expiration date for use.

C. Clean concrete surfaces to receive expansion joint compound in accordance with the printed instructions of the joint compound manufacturer.

1.05. DELIVERY, STORAGE, AND HANDLING

- A. Transport, handle and deliver materials to the job site in the manufacturer's sealed bags, unopened containers or banded pallets.
- B. Store materials off the ground on a platform or skids and protect with covers from snow, rain and ground splatter.
- C. Store expansion joint compounds in a dry location where they cannot freeze.
- D. Store plastic products under cover in a dry location, out of direct sunlight.

1.06. MANUFACTURER SERVICES

- A. Prior to joint preparation for joints receiving sealant materials, require joint manufacturer's technical representative to demonstrate, on site, joint preparation, priming, and sealant materials application for the Contractor's personnel performing joint work.

PART 2 - PRODUCTS

2.01. PVC WATERSTOP

- A. Waterstops shall be extruded from a PVC compound and shall be flat ribbed or ribbed with center-bulb. Waterstop shall comply with Corps of Engineers Specification CRD-C-572.
- B. PVC waterstops for construction joints:
 - 1. Flat ribbed type, 6 inches wide unless otherwise noted on the Contract Drawings, with a minimum thickness of 3/8-inches. Products:
 - a. Greenstreak; Model 679.
 - b. BoMetals, Inc.; Model FR-638.
 - c. Vinylex; Model R638.
 - d. Or accepted equivalent product.
 - 2. Flat ribbed type, 4 inches wide unless otherwise noted on the Contract Drawings, with a minimum thickness of 3/16-inches. Products:

- a. Greenstreak; Model 781.
 - b. BoMetals, Inc.; Model FR-431.
 - c. Vinylex; Model R4316T.
 - d. Or accepted equivalent product.
- C. Provide waterstops resistant to chemical action with portland cement, alkalies, acids, and not affected by mildew or fungi. It shall show no effect when immersed for 10 days in a 10 percent solution of sulfuric or hydrochloric acid, saturated lime solution or salt water. Waterstops shall be such that any cross section will be dense, homogeneous, and free from porosity and other imperfections. They shall be symmetrical in shape. When tested in accordance with Federal Standard No. 601, the material shall meet the requirements in Table 1 below.

TABLE 1	
Requirement	ASTM Spec.
Tensile strength, 1,600 psi	D638
Hardness, Shore durometer, 70-80	D2240
Elongation, ultimate, 300 percent to 450 percent	D638
Water absorption, dry weight, maximum (48 hours) 0.15 percent	D570
Specific gravity, 1.3 to 1.4	D792
Stiffness in flexure, 600 psi	D747
Cold brittleness, -35 degrees F	D746
Tear resistance, 300 lbs/inch	D624

2.02. HYDROPHILIC RUBBER WATERSTOP

- A. Provide a bentonite free rubber waterstop. Waterstop shall expand by a minimum of 80 percent of dry volume in the presence of water to form a watertight joint seal without damaging the concrete in which it is cast. Provide minimum concrete cover as recommended by the waterstop manufacturer.

1. Products:

- a. Adeka; Ultraseal MC-2010MN.

- b. Greenstreak; Hydrotite CJ-1020-2K.
- c. Or accepted equivalent product.

2.03. ELASTOMERIC JOINT SEALANT

- A. Federal Specification TT-S-00230C Type 1, Class A, single component, cold applied, pourable, polyurethane.

1. Products:

- a. Euclid Chemical Corp; Eucolastic 1.
- b. Mameco ; Vulkem 45.
- c. Or accepted equivalent product.

2.04. JOINT SEALANT FOR CONCRETE STRUCTURES

- A. Joint sealant shall be a multipart, gray, nonstaining, nonsagging, gun grade polyurethane sealant, which cures at ambient temperature to a firm, flexible, resilient, tear-resistant rubber. Sealant shall comply with ASTM C920, Type M, Grade P, Class 25 for horizontal joints and Grade NS, Class 25 for vertical joints and be recommended by the manufacturer for continuous immersion in water. Troweling of sealants into joints will not be permitted. Sealant shall meet requirements in Table 2.

TABLE 2	
Characteristic or Parameter	Technical Requirements
Pot life	1 to 3 hours
Hardness	25 Shore A, +/- 5
Elongation	500 percent, ASTM D412
Tensile strength	95 psi, ASTM D412
Peel strength on concrete	No adhesion loss at 25 pounds
Temperature service range	-40 to 170 degrees F
Immersion in water	Continuous

B. Products:

- 1. Sika Corporation; Sikaflex-2c SL (for horizontal joints; Type M, Grade P, Class 25)

2. Sika Corporation; Sikaflex-2c NS (for vertical joints; Grade NS, Class 25).
3. Or accepted equivalent product.

2.05. BACKING ROD FOR EXPANSION JOINTS

- A. Provide an extruded closed-cell polyethylene foam rod. The rod shall be 1/4-inch larger in diameter than the joint width. Where possible, provide full-length sections for the joint; minimize splices:
 1. Industrial Systems Department; Minicel backer rod.
 2. Hercules, Inc.; Plastic Products Group.

2.06. EPOXY JOINT SEALANT

- A. 100 percent solids per ASTM D1259, two-part epoxy with an instantaneous Shore D hardness of 50 to 65 per ASTM D2240.
 1. Metzger-McGuire Co.; MM80 or Edge Pro50.
 2. Euclid Chemical Corp. ; Euco700.
 3. Or accepted equivalent product.

2.07. BOND BREAKER TAPE

- A. Provide an adhesive-backed glazed butyl or polyethylene tape that will adhere to the premolded joint material or concrete surface. The tape shall be the same width as the joint. The tape shall be compatible with the sealant.

2.08. PREFORMED CONTROL JOINTS

- A. One-piece, flexible, PVC joint former.
 1. Vinylex Corp.; Kold-Seal Zip-Per Strip KSF-150-50-50.
 2. Or accepted equivalent product.
- B. One-piece steel strip with preformed groove:
 1. Burke Concrete Accessories, Inc.; Keyed Kold Retained Kap.

- 2. Or accepted equivalent product.
- C. Provide the preformed control joint material in full-length unspliced pieces.
- 2.09. PREMOLDED JOINT FILLER FOR BELOW GRADE
 - A. Joint filler shall be preformed, nonextruded type constructed of closed-cell neoprene conforming to ASTM D1752, Type I.
 - B. Bituminous-type preformed expansion joint filler conforming to ASTM D994.
- 2.10. PREMOLDED JOINT FILLER FOR EXPOSED ABOVE GRADE
 - A. Self-expanding cork per ASTM D1752, Type III.
 - B. Sponge rubber per ASTM 1752, Type I. Preformed, nonextruded type constructed of closed-cell neoprene.
- 2.11. VOC LIMITS FOR SEALANTS AND SEALANT PRIMERS
 - A. VOC limits for sealants, and sealant primers to comply with content limits when calculated according to 40 CFR 59, Subpart D (EPA Method 24), or applicable state and local codes containing more stringent requirements.
- 2.12. BOND BREAKER FOR JOINT COMPOUNDS
 - A. Provide polyethylene tape.

PART 3 - EXECUTION

- 3.01. PVC WATERSTOPS
 - A. Heat splice at ends and intersections. Provide waterstops that provide a continuous, uninterrupted watertight diaphragm throughout the entire joint system below the high water level and below grade, unless noted otherwise on the Drawings.
 - B. Construct forms for construction joints to prevent injury to waterstops. Hold waterstops securely in position in the construction joints by wire ties, continuous bars, and rings as shown on the Contract Drawings. Install waterstops in construction joints in hydraulic structures and as shown on the Contract Drawings.

- C. Use factory-made crosses, tees and ells. Make field splices with a thermostatically controlled heating iron in conformance with the manufacturer's current recommendations. Allow at least 10 minutes before pulling or straining the new splice in any way. The finished splices shall provide a cross section that is dense and free of porosity with tensile strength of not less than 80 percent of the unspliced materials.
- D. Provide waterstops with an integral fastening system consisting of grommets or pre-punched holes.

3.02. JOINTS

- A. Make joints only at locations shown on the Contract Drawings or as permitted by the Engineer. Any addition or relocation of construction joints proposed by the Contractor, must be submitted to the Engineer for written approval.
- B. Cast slabs and beams monolithically without horizontal joints unless specifically indicated on the drawings.
- C. Do not use horizontal joints within foundation mats, base slabs, footings, pile caps, slabs on grade or elevated beams and slabs.
- D. Provide joints in concrete fills and toppings at the same location as the joints in the supporting concrete.
- E. Provide waterstops in all wall and slab joints in liquid containment structures and at locations shown on the Contract Drawings. Do not provide metal waterstops unless permitted by Engineer.
- F. Construction Joints:
 - 1. Provide waterstops at construction joints where shown on the Contract Drawings and specified herein.
 - 2. Allow 48 hours between pours of adjacent slabs.
 - 3. After the pour has been completed to the construction joint and the concrete has hardened, thoroughly clean the entire surface of the joint of surface laitance, loose concrete, foreign material, and expose clean aggregate by waterblasting the surface of construction joints before placing the new concrete.

4. In case of emergency, place additional construction joints. (An interval of 45 minutes between two consecutive batches of concrete shall constitute cause for an emergency construction joint.)

G. Control Joints:

1. Do not use control joints in hydraulic structures.
2. Locate control joints as shown on the Contract Drawings.
3. Form control joints with control joint inserts or saw cuts.
4. For saw cutting:
 - a. Using early entry saws, saw joints in slabs before the formation of uncontrolled cracking (i.e., cracking that occurs at locations other than construction, control, or contraction joints) and as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing.
 - b. Fill saw cut to full depth with elastomeric joint sealant for joints not exposed to vehicular traffic. Fill joints to full depth with epoxy joint sealant for joints exposed to vehicular traffic.
5. Unless noted otherwise on the Contract Drawings, total reduction in concrete member thickness shall be at least 1/4 the member thickness.

3.03. INSTALLATION OF JOINT SEALANTS

- A. Immediately before installing the joint sealant, clean the joint cavity by sandblasting or power wire brushing. Install bond breaker tape per manufacturer's instructions.
- B. Apply masking tape along the edges of the exposed surface of the exposed joints.
- C. Application criteria for the sealant materials, such as temperature and moisture requirements and primer cure time, shall be in accordance with the recommendations of the sealant manufacturer.
- D. After the joints have been prepared as described above, apply the joint sealant. Apply the primer, if required, and joint sealant only with the equipment and methods recommended by the joint sealant manufacturer.

- E. Trowel the joints smooth with a tuck pointing tool wiped with a solvent recommended by the sealant manufacturer.
- F. After the sealant has been applied, remove the masking tape and any sealant spillage.
- G. Sealants used in water retaining structures shall achieve final cure at least seven days before the structure is filled with water.

3.04. FIELD QUALITY CONTROL

- A. Contractor shall notify the Owner or Construction Manager of readiness for items under this Section to be inspected a minimum of 5 working days prior to the items being covered by further work. Failure to provide this notification will be cause for delay in placing until observations can be completed.

END OF SECTION

SECTION 03 21 00

REINFORCEMENT BARS

PART 1 - GENERAL

1.01. DESCRIPTION

A. Provide concrete reinforcement as indicated and specified:

B. Section Includes:

1. Reinforcement bars.
2. Reinforcement accessories.

1.02. REFERENCES

A. American Society for Testing and Materials (ASTM):

1. A615: Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
2. A706: Standard Specification for Low Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
3. A970: Standard Specification for Headed Steel Bars for Concrete Reinforcement.

B. American Concrete Institute (ACI):

1. 301: Standard Specification for Structural Concrete.
2. 315: Details and Detailing of Concrete Reinforcement.
3. 318: Building Code Requirements for Structural Concrete.
4. 350: Building Code Requirements for Environmental Engineering Concrete Structures.
5. SP-66: ACI Detailing Manual.

C. Concrete Reinforcing Steel Institute (CRSI):

1. Manual of Standard Practice.
 2. Placing Reinforcing Bars.
- D. Where reference is made to one of the above standards, the version in effect at the time of bid opening shall apply.

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Unless otherwise acceptable to the Engineer, each submittal shall include reinforcement only for the individual structure to which it pertains.
- C. Shop Drawings:
 1. Submit bar lists and placing drawings for all reinforced concrete structures in accordance with Section 01 33 00.
 2. Detail reinforcement in conformance with ACI SP-66.
 3. Clearly indicate bar sizes, spacings, locations and quantities of reinforcement steel, bending schedules, and supporting and spacing devices. Show joints, with applicable joint reinforcement.
 4. Coordinate bar splicing and placement with Contractor's concrete placing schedule and joint locations. Do not add or delete joints without permission from the Engineer.
 5. Show wall reinforcement in elevation.
 6. Show slab reinforcement in plan view.
 7. Show location and size of all penetrations greater than 12-inches in diameter or least dimension of the opening with the corresponding added reinforcement around the penetrations.
 8. Clearly show marking for each reinforcement item.
 9. Indicate locations of reinforcement bar cut-offs, splices and development lengths.

- D. Submit certified copies of mill test reports of reinforcement analysis for each shipment of reinforcement with specific lots in shipments identified.
- E. Chemical composition of reinforcement steel: Ladle analysis indicating percentage of carbon, phosphorous, manganese and sulfur present in steel.
- F. Where mechanical couplers are required or permitted to be used to splice reinforcement steel, submit Manufacturer's literature that contains instructions and recommendations for installation for each type of coupler used; certified test reports that verify the load capacity of each type and size of coupler used; and Shop Drawings that show the location of each coupler with details of how they are to be installed in the formwork.
- G. Where reinforcing bar end anchors are required or permitted to be used, submit Manufacturer's literature with complete data on material and procedures; certified test reports that verify the load capacity of each type and size of end anchor used; and Shop Drawings that show the location of each end anchor with details of the bar grade and size number to be anchored.

1.04. QUALITY ASSURANCE

- A. Do not fabricate reinforcement until shop and placement drawings have been reviewed and accepted by the Engineer.
- B. Perform concrete reinforcement work in accordance with CRSI Manual of Standard Practice.
- C. In no case shall any reinforcement steel be covered with concrete until the installation of the reinforcement has been observed by the Engineer and the Engineer's authorization to proceed with the concreting has been obtained. The Engineer shall be given 5 working days minimum prior notice of the readiness of placed reinforcement for observation. The forms shall be kept open until the Engineer has finished observations of the reinforcement steel.

1.05. DELIVERY, STORAGE, AND HANDLING

- A. Keep reinforcement steel free from mill scale, rust, dirt, grease or other foreign matter.
- B. Ship and store reinforcement steel with bars of the same size and shape fastened in bundles with durable tags, marked in a legible manner with waterproof markings

showing the same "mark" designations as those shown on the submitted placing drawings.

- C. Store reinforcement steel off the ground, protected from moisture and kept free from dirt, oil or other injurious contaminants.

PART 2 - PRODUCTS

2.01. REINFORCEMENT STEEL

- A. Reinforcement Steel: ASTM A615/A615M, 60 ksi yield grade; deformed billet steel bars, unfinished.
 - 1. Provide support bars and reinforcement bar supports as specified herein to obtain the concrete cover indicated.

2.02. ACCESSORY MATERIALS

- A. Tie Wire: Minimum 16 gage annealed type.
- B. Chairs, Bolsters, Bar Supports, and Spacers: sized and shaped for strength and support of reinforcement during concrete placement.
- C. Special Chairs, Bolsters, Bar Supports, and Spacers Adjacent to Weather Exposed Concrete Surfaces: plastic coated steel, stainless steel, or plastic type; size and shape.
- D. Provide 3-inch by 3-inch plain precast concrete blocks, precast concrete doweled blocks or concrete brick for support of bottom reinforcement in foundation mats, base slabs, footings, pile caps, grade beams and slabs on grade. Provide block thickness to produce concrete cover of reinforcement as indicated.
- E. Mechanical Couplers:
 - 1. Reinforcement Tension Bar Splicers:
 - a. Manufacturers: Cadweld or Lenton rebar splicers by Erico Products, Inc. and Dayton Barsplice, Inc.
 - b. Manufacturers: DB-SAE splicer system by Richmond Screw Anchor Company, Inc., C2D rebars flange coupler by Williams Form Engineering Corporation and Lenton Form Saver by Erico Products, Inc.

- c. Develop minimum 125 percent of yield capacity of bars spliced in tension when tested as assembly in accordance with ASTM A370 and A615.
 2. Reinforcement Compression Bar Splicers:
 - a. Manufacturers: G-Loc splicers by Gateway Building Products Division and Speed-Sleeve by Erico Products, Inc.
- F. Headed Reinforcing Bar Anchors (If Used):
1. Manufacturers: Lenton Terminator by Erico Products, Inc.; or approved equal.
 2. Each Headed Reinforcing Bar Anchor shall consist of the following factory assembled components:
 - a. Internally threaded cylindrical “Head”, fabricated to meet ASTM A970. The Head shall be a D16 Lenton Terminator, with the following geometry, or approved equal.
- | Bar Size | Height of Head (min) | Outside Diameter of Head (min) |
|----------|----------------------|--------------------------------|
| #9 | 1.50” | 2.75” |
- b. The internal threads of the Head shall be capable of developing a tension force in the reinforcing bar not less than the lesser of the following:
 - (1) 95 percent of the ultimate tensile strength of the reinforcing bar
 - (2) 160 percent of the specified yield strength of the reinforcing bar.
 - c. A length of ASTM A615 or A706, Grade 60, reinforcing with one end threaded to fully accept the Head specified above. The length of bar shall be as indicated on the Drawings.
 - d. As a minimum the Headed Reinforcing Bar Anchor Assembly Fabricator shall be responsible for the following. Only “Head” manufacturer approved Fabricators are permitted to fabricate and assemble Headed Reinforcing Bar Anchors.
 - (1) Provide and fabricate the required length of reinforcing bar, as specified here-in and as indicated on the drawings.

- (2) Thread the appropriate end(s) of the reinforcing bar to accept the manufacturer provided and Engineer approved "Head".
- (3) Assemble the two components and torque them as specified by the "Head" manufacturer.
- (4) The Assembly Fabricator shall adhere to the additional requirements of the "Head" manufacturer.

e. Only Fabricators who are approved by the Head component manufacturer are acceptable to perform this work.

G. Provide adhesive for anchoring reinforcement bars where indicated on the Drawings. The adhesive product used shall be as required by Section 05 50 00.

2.03. FABRICATION

- A. Fabricate concrete reinforcement in accordance with CRSI Manual of Standard Practice.
- B. Weld reinforcement in accordance with AWS D1.4 only when permitted by the Engineer.
- C. Locate reinforcement splices not indicated on Drawings, at point of minimum stress. Review location of splices with Engineer.
- D. Cold bend bars. Do not straighten or rebend bars.
- E. Do not heat reinforcement steel to bend or straighten.
- F. Bend bars around a revolving collar having a diameter of not less than that recommended by the ACI 318.

PART 3 - EXECUTION

3.01. INSTALLATION

- A. Place, support and secure reinforcement against displacement. Do not deviate from required position. Place reinforcement a minimum of 2 inches clear of any metal pipe or fittings.

- B. Position dowels accurately. Rigidly support, align and securely tie dowels normal to the concrete surface before concrete placement. Setting dowels into wet concrete is prohibited.
- C. Bars additional to those indicated that may be found necessary or desirable by the Contractor for the purpose of securing reinforcement in position shall be provided by the Contractor at no additional cost to the Owner.
- D. Provide additional reinforcement bars to support top reinforcement in slabs. Do not shift reinforcement bars from positions in upper layers to positions in lower layers as a substitute for additional support bars.
- E. Support reinforcement steel in accordance with CRSI "Placing Reinforcement Bars" with maximum spacing of 4 feet-0 inches.
- F. Tie reinforcement steel at intersections in accordance with CRSI "Placing Reinforcement Bars":
 - 1. Maximum tie spacing for footings, walls and columns: every third intersection or 3 feet-0 inches.
 - 2. Maximum spacing for slabs and other work: every fourth intersection or 3 feet-0 inches.
 - 3. Tie a minimum of 25 percent of all intersecting bars in foundation mats, base slabs, footings, pile caps, slabs on grade and elevated slabs.
 - 4. Secure all dowels in place before placing concrete.
 - 5. Tie wires shall be bent away from the forms and from finished concrete surfaces in order to provide the required concrete coverage.
- G. Locate reinforcement to avoid interference with items drilled in later, such as concrete anchors.
- H. Mechanical coupler systems may be substituted for dowels at Contractor's option when permitted by Engineer.
- I. Provide additional reinforcement bars to support ties and stirrups in beams where top reinforcement is not continuous.

- J. Securely support and tie reinforcement steel to prevent movement during concrete placement.
- K. Unless otherwise shown on the Drawings or permitted by the Engineer, do not bend reinforcement bars that project from in-place concrete.
- L. Do not weld reinforcement steel bars (including tack welded) either during fabrication or erection unless specifically shown on the Drawings or specified herein, or unless prior written permission has been obtained from the Engineer. Immediately remove bars that have been welded, including tack welds, without such permission from the work.
- M. Reinforcement steel interfering with the location of other reinforcement steel, conduits or embedded items may be moved within the specified tolerances or one bar diameter, whichever is greater. Make greater displacement of bars to avoid interference only with the permission of the Engineer. Do not cut reinforcement to install inserts, conduits, mechanical openings or other items without the prior permission from the Engineer.
- N. Reinforcement shall be clean and free from loose mill scale, dirt, grease, oil, form release agent, dried concrete or any material reducing bond with concrete.
- O. Setting bars on layers of fresh concrete as the work progresses or adjusting reinforcement during the placement of concrete is prohibited.
- P. Provide and place safety caps on all exposed ends of vertical reinforcement that pose a danger to injury or life safety.

3.02. CONCRETE COVER OVER REINFORCEMENT BARS

- A. Refer to the Drawing for concrete cover over reinforcement.

3.03. REINFORCEMENT AROUND OPENINGS AND PENETRATIONS

- A. Accommodate placement of formed openings and penetrations.
- B. Unless specific additional reinforcement around openings and penetrations is shown on the Drawings, provide additional reinforcement steel on each side of opening or penetration equivalent to one half of the cross-sectional area of the reinforcement steel interrupted by an opening or penetration. The bars shall have sufficient length to be fully developed at each end beyond the opening or penetration.

- C. Refer to details on Drawings for additional diagonal bars around openings or penetrations and bar extension length on each side of openings or penetrations.

3.04. SPLICING OF REINFORCEMENT

- A. Splices may be used to provide continuity due to bar length limitations. Minimum length of bars spliced for this reason is 30 feet. Do not splice reinforcement that is detailed to be continuous in the Drawings.
- B. Stagger bar splices.
- C. ACI 318 Class B Splices shall be used unless noted otherwise.
- D. Make reinforcement continuous through construction joints.
- E. Reinforcement may be spliced at construction joints provided that entire lap is placed within only one concrete placement.

3.05. ACCESSORIES

- A. Provide accessories such as chairs, chair bars and the like in sufficient quantities and strength to adequately support the reinforcement and prevent its displacement during the erection of the reinforcement and the placement of concrete.
- B. Use precast concrete blocks where the reinforcement steel is to be supported over soil.
- C. Provide stainless steel bar supports or steel chairs with plastic tips where the chairs are set on forms for a concrete surface that will be exposed to weather, high humidity or liquid (including bottom of slabs over liquid containing areas) unless otherwise noted on contract documents.
- D. Do not use metal chairs, ferrous clips, nails, etc. that extend to the surfaces of the concrete. Do not use stones, brick or wood block supports.
- E. Do not use alternate methods of supporting top steel in slabs, such as steel channels supported on the bottom steel or vertical reinforcement steel fastened to the bottom and top mats unless permitted by the Engineer.
- F. Mechanical Couplers:
 - 1. Couplers that are located at a joint face can be a type that can be set either flush or recessed from the face as indicated.

2. Seal couplers during concrete placement to completely eliminate concrete or cement paste from entering.
3. Recess couplers intended for future connections a minimum of 1/2 inch from the concrete surface. After the concrete is placed, plug the coupler with plastic plugs that have an O-ring seal and the recess filled with sealant to prevent any contact with water or other corrosive materials.
4. Unless indicated otherwise, provide mechanical coupler spacing and size to match the spacing and size of the reinforcement indicated for the adjacent section.

G. Headed Reinforcing Bar Anchors (If Used):

1. Use reinforcing bar end anchors where indicated on the Drawings or accepted by the ENGINEER.
2. Install only fully fabricated and assembled Headed Reinforcing Bar Anchors as specified in Article 2.02, above.
3. Provide clear cover over reinforcing bar end anchors of not less than indicated on the Drawings or specified for the bars when measured from the surface of the concrete to the outside of the reinforcing bar end anchor.

3.06. FIELD QUALITY CONTROL

- A. Contractor shall notify the Owner or Owner's Representative of readiness for items under this Section to be inspected a minimum of five working days prior to the items being covered by further work. Failure to provide this notification will be cause for delay in placing until observations can be completed.
- B. Remove reinforcement with kinks or bends not shown on shop or placement drawings. Remove such reinforcement from job site and replace with new fabricated steel. Do not field bend reinforcement unless reinforcement is indicated or specified to be field bent.
- C. Protect reinforcement from rusting, deforming, bending, or kinking as determined by the Construction Manager. Clean in-place reinforcement that has rusted or splattered with concrete using sand or water blasting prior to incorporation into the Work.

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.01. DESCRIPTION

- A. Provide labor, materials, equipment and incidentals necessary to furnish and install cast-in-place concrete as specified and as shown on the Contract Drawings.

1.02. REFERENCES

- A. American Concrete Institute (ACI):

1. 211.1: Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete.
2. 214R: Recommended Practice for Evaluation of Strength Test Results of Concrete.
3. 301: Standard Specifications for Structural Concrete.
4. 304R: Guide for Measuring, Mixing, Transporting and Placing Concrete.
5. 304.2R: Placing Concrete by Pumping Methods.
6. 305R: Hot Weather Concreting.
7. 306R: Cold Weather Concreting.
8. 308: Standard Practice for Curing Concrete.
9. 309R: Guide for Consolidation of Concrete.
10. 311.4R: Guide for Concrete Inspection.
11. 318: Building Code Requirements for Structural Concrete.
12. 350: Code Requirements for Environmental Engineering Concrete Structures.

- B. American Society for Testing and Materials (ASTM):

1. C31: Standard Practice for Making and Curing Concrete Test Specimens in the Field.
2. C33: Standard Specification for Concrete Aggregates.
3. C39: Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
4. C40: Standard Test Method for Organic Impurities in Fine Aggregates for Concrete.
5. C42: Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
6. C87: Standard Test Method for Effect of Organic Impurities in Fine Aggregate on Strength of Mortar.
7. C88: Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
8. C94: Standard Specification for Ready-Mixed Concrete.
9. C109: Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in or [50-mm] Cube Specimens).
10. C123: Standard Test Method for Lightweight Particles in Aggregate.
11. C136: Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
12. C138: Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete.
13. C143: Standard Test Method for Slump of Hydraulic Cement Concrete.
14. C157: Standard Test Method for Length Change of Hardened Hydraulic Cement, Mortar and Concrete.
15. C171: Standard Specification for Sheet Materials for Curing Concrete.
16. C172: Standard Practice for Sampling Freshly Mixed Concrete.
17. C192: Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.

18. C231: Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
19. C260: Standard Specification for Air-Entraining Admixtures for Concrete.
20. C289: Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method).
21. C295: Standard Guide for Petrographic Examination of Aggregates for Concrete.
22. C309: Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
23. C311: Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland Cement Concrete.
24. C494: Standard Specification for Chemical Admixtures for Concrete.
25. C595: Standard Specification for Blended Hydraulic Cements.
26. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete.
27. C881: Standard Test Method for Epoxy Resin Base Bonding Systems for Concrete.
28. C882: Standard Test Method for Bond Strength of Epoxy Resin Systems Used with Concrete by Slant Shear.
29. C1017: Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
30. C1064: Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete.
31. C1107: Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
32. D75: Standard Practice for Sampling Aggregates.
33. E154: Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover.

34. E1745: Standard Specification for Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.

35. E329: Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials used in Construction.

C. American Association of State Highway and Transportation Officials (AASHTO):

1. M182: Standard Specification for Burlap Cloth Made from Jute or Kenaf and Cotton Mats.

1.03. SUBMITTALS

A. Make submittals in accordance with the General Conditions and Section 01 33 00.

B. Testing required under Article 1.03 is the responsibility of the Contractor and shall be provided at no additional cost to the Owner.

C. If during the progress of the work the materials from the sources originally accepted change in characteristics, the Contractor shall at their own expense make new acceptance tests of aggregate and establish new design mixes.

D. If during the progress of the work it is impossible to secure concrete of the required workability and strength with the materials being furnished, the Engineer may order changes in proportions, materials or both, as may be necessary to secure the desired properties. All changes so ordered shall be made at the Contractor's expense.

E. Plant Qualification: Submit certification from the National Ready Mixed Concrete Association indicating compliance with the specified qualification requirements.

F. Product Data:

1. Manufacturer's specifications and instructions including ASTM Standards conformance and Material Safety Data Sheets (MSDS) for admixtures and curing materials. Manufacturer's certification of compatibility of all admixtures.

2. Manufacturer's catalogue cuts, technical data, storage requirements, product life, working time after mixing, temperature considerations, conformity to referenced ASTM standards, and Material Safety Data Sheet for non-shrink grout.

G. Shop Drawings:

1. Provide certificate that cement used complies with ASTM C595 and these specifications.
2. Provide certificates that aggregates comply with required ASTM standards. Submit gradation analysis with concrete mix designs. Include source/location of aggregates.
3. Provide certificate of compliance with these specifications from the manufacturer of the concrete admixtures.
4. For each formulation of concrete proposed, provide concrete mix designs and laboratory 7-day and 28-day compressive tests, or submit test results of 7- and 28-day compressive tests of the mix where the same mix has been used on two previous projects in the past twelve months.
5. As a minimum each concrete mix design submittal shall include, but is not limited to containing the following information.
 - a. 7-day and 28-day compression test results. Include standard deviation for test results on each 7 or 28-day group.
 - b. Constituent quantities per cubic yard.
 - c. Water cementitious materials ratio.
 - d. Concrete slump.
 - e. Air content.
 - f. Water soluble chloride ion content of any individual components of the proposed mix.
 - g. Type of concrete mix.
 - h. Manufacturer of cementitious products.
 - i. Sources of cement, pozzolan, and aggregates.
 - j. Letter certifying that the admixtures used in the same concrete mix are compatible with each other, as well as the aggregates.
6. Submit layout for joints and plan for joint surface preparation.

7. Proposed special procedures for protection of concrete under wet weather placement conditions.
8. Proposed special procedures for protection and curing of concrete under hot and cold weather conditions.

H. Manufacturers' Instructions:

1. Provide epoxy bonding compound manufacturer's specific instructions for use. Provide manufacturer's data sheets as to suitability of product to meet job requirements with regard to surface, pot life, set time, vertical or horizontal application, and forming restrictions.

I. Field Quality Control Submittals:

1. Provide delivery tickets for ready-mix concrete or weighmasters certificate per ASTM C94, including weights of cement and each size aggregate and amount of water added at the plant and record of pours. Record the amount of water added on the job on the delivery ticket. Water added at the plant shall account for moisture in both coarse and fine aggregate. If it is necessary to add water to obtain the specified slump, add water per ASTM C94, but do not exceed the water content of the reviewed design mix.

1.04. QUALITY ASSURANCE

A. Unless otherwise indicated, materials, workmanship, and practices shall conform to the following standards:

1. ACI 301, "Structural Concrete for Buildings."
2. ACI 318, "Building Code Requirements for Reinforced Concrete."
3. ACI 350, "Code Requirements for Environmental Engineering Concrete Structures."

B. Where provisions of pertinent codes and standards conflict with this specification, the more stringent provisions govern.

C. Concrete not meeting the minimum specified 28-day design strength shall be cause for rejection and removal from the Work.

D. Perform concrete work in conformance with ACI 301 unless otherwise specified.

- E. Do not use admixtures, including calcium chloride, which will cause accelerated setting of cement in concrete.
- F. Do not place concrete until design mix, material tests and trial concrete batch mix compression test results are accepted by the Engineer.
- G. Employ an independent testing laboratory, acceptable to the Engineer, to develop concrete mix designs and testing. Concrete testing shall be performed by an ACI Concrete Field Technician, Grade I or equivalent. Refer to Article 1.03 above.
- H. The Contractor shall employ an independent testing laboratory to perform field testing in order to verify conformity of materials to specifications. Field concrete testing shall be performed by an ACI Concrete Field Technician, Grade I or equivalent. Allow free access to obtain test samples.
- I. Concrete samples to be taken as part of the required Field Testing, shall be taken at the point of placement.
- J. Methods of Sampling and Testing:
 - 1. Fresh Concrete Sampling: ASTM C172.
 - 2. Specimen Preparation: ASTM C31.
 - 3. Compressive Strength: ASTM C39.
 - 4. Air Content: ASTM C231.
 - 5. Slump: ASTM C143.
 - 6. Temperature: ASTM C1064.
 - 7. Unit Weight: ASTM C138.
 - 8. Obtaining Drilled Cores: ASTM C42.
- K. Acceptance of Structure: Acceptance of completed concrete work requires conformance with dimensional tolerances, appearance and strength as indicated or specified.
- L. Hot weather concrete to conform to ACI 305R and as specified herein.
- M. Cold weather concrete to conform to ACI 306R and as specified herein.

- N. Reject concrete delivered to job site that exceeds the time limit or temperature limitations specified.
- O. Do not place concrete in water or on frozen or uncompacted ground.
- P. Workability:
 - 1. Concrete shall be of such consistency and composition that it can be worked readily into the forms and around the reinforcement without excessive vibrating and without permitting the materials to segregate or free water to collect on the surface.
 - 2. Adjust the proportions to secure a plastic, cohesive mixture, and one that is within the specified slump range and water cementitious ratio.
 - 3. To avoid unnecessary changes in consistency, obtain the aggregate from a source with uniform quality, moisture content, and grading. Handle materials to minimize variations in moisture content that would interfere with production of concrete of the established degree of uniformity and slump.

1.05. DELIVERY, STORAGE, AND HANDLING

- A. Deliver concrete to discharge locations in watertight agitator or mixer trucks without altering the specified properties of water-cement ratio, slump, air entrainment, temperature and homogeneity.
- B. Reject concrete not conforming to specification, unsuitable for placement, exceeding the time or temperature limitations or not having a complete delivery batch ticket.

1.06. SITE CONDITIONS

- A. Do not place concrete until conditions and facilities for making and curing control test specimens are in compliance with ASTM C31 and as specified herein.

PART 2 - PRODUCTS

2.01. MATERIALS

- A. Cement:
 - 1. ASTM C595, Type IL blended Portland Limestone Cement.

2. Use only one brand of cement in any individual structure. Use no cement that has become damaged, partially set, lumpy, or caked. Reject the entire contents of the sack or container that contains such cement. Use no salvaged or reclaimed cement.
3. Maximum tricalcium aluminate shall not exceed 8 percent. The maximum percent alkalis shall not exceed 0.6 percent.

B. Fly Ash:

1. Where fly ash is included in the mix, the fly ash content shall be no less than 15 percent, nor more than 20 percent of the total cement plus pozzolan content by weight.
2. Provide fly ash conforming to the following requirements:
3. Class F fly ash conforming to ASTM C618 for chemical and physical properties.
4. Supplemental requirements in percent:
 - a. Maximum carbon content: 3 percent.
 - (1) Maximum sulfur trioxide (SO₃) content: 4 percent.
 - (2) Maximum loss on ignition: 3 percent.
 - (3) Maximum water requirement (as a percent of control): 100 percent

C. Fine Aggregates:

1. Clean, sharp, natural sand conforming to requirements of ASTM C33 with a fineness modulus between 2.50 and 3.0.

D. Coarse Aggregate:

1. Well graded crushed stone, natural rock conforming to requirements of ASTM C33.
2. Limit deleterious substances in accordance with ASTM C33, Table 3, Severe Weathering Regions, limit clay lumps not to exceed 1.0 percent by weight, and limit loss when tested for soundness using magnesium sulfate to 12 percent.

E. Water and Ice:

1. Use water and ice free from injurious amounts of oil, acid, alkali, salt, organic matter or other deleterious substances and conforms to requirements of ASTM C94.
2. Water shall not contain more than 500 mg/L of chlorides nor more than 500 mg/L of sulfate.
3. Heat or cool water to obtain concrete temperatures specified, and in conformance with ACI 305R and ACI 306R.

F. Concrete Admixtures:

1. Maintain compressive strength and maximum water-cement ratios specified in Table 03 30 00-1 when using admixtures. Include admixtures in solution form in the water-cement ratio calculations.
2. Do not use any admixture that contains chlorides or other corrosive elements in any concrete. Admixtures shall be nontoxic after 30 days.
3. Hydration controlling admixtures may be used but shall be submitted for approval and identified clearly on all batch tickets.
4. Use admixtures in compliance with the manufacturer's printed instructions. The manufacturer shall certify the compatibility of multiple admixtures used in the same mix.
5. Do not use admixtures in greater dosages than recommended by manufacturer.
6. Two or more admixtures specified may be used in the same mix provided that the admixtures in combination retain full efficiency and have no deleterious effect on the concrete or on the properties of each other.
7. Air Entrainment:
 - a. Class A concrete; an air-entraining admixture conforming to ASTM C260.
 - b. Products:
 - c. BASF Corporation; MB-AE 90.
 - d. Sika Corporation, AER.

- e. Or accepted equivalent product.
 - f. Adjust the admixture content to accommodate fly ash or pozzolan requirements, and other admixtures when used, in order to obtain the specified air content.
8. Water Reducing:
- a. For Class A concrete a water-reducing admixture conforming to ASTM C494, Type A and compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.
 - b. Products:
 - (1) BASF Corporation; Polyheed Series.
 - (2) Sika Corporation, Plastocrete 161.
 - (3) WR Grace & Co.;Darex II-AEA.
 - (4) Euclid Chemical Company; Eucon NW.
 - (5) Or accepted equivalent product.
9. Water Reducing and Retarding:
- a. For Class A concrete a water-reducing and retarding admixture conforming to ASTM C494, Type D and compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.
 - b. Products:
 - (1) BASF Corporation; Pozzolith Series.
 - (2) Sika Corporation; Plastiment.
 - (3) Euclid Chemical Company; Eucon WR-91.
 - (4) Or accepted equivalent product.
10. High-Range Water-Reducing Admixture (Superplasticizer):

- a. For Class A concrete a High-Range water-reducing admixture conforming to ASTM C494, Type F or ASTM C1017, Type I.
- b. Products:
 - (1) BASF Corporation; Glenium Series.
 - (2) WR Grace & Co.; Daracem 100.
 - (3) Euclid Chemical company; Eucon SPC.
 - (4) Or accepted equivalent product.

G. Hydration Controlling Admixture:

- 1. Hydration controlling admixture conforming to ASTM C494 and compatible with the air-entraining admixtures. The amount of admixture added to the concrete shall be in accordance with the manufacturer's recommendations.
- 2. Products:
 - a. BASF Corporation; DELVO Stabilizer.
 - b. Sika Corporation; SikaTard 440.
 - c. Or accepted equivalent product.

H. Epoxy Bonding Agent:

- 1. Epoxy bonding agent shall conform to ASTM C881 Type I, II, IV or V; Grade 2 for epoxy resin adhesives. The class of epoxy bonding agent shall be suitable for ambient and substrate temperatures.
- 2. Products:
 - a. Sika Corp.; Sikadur 32.
 - b. Euclid Chemical Company; Duralcrete.
 - c. BASF Corporation, Concreactive Liquid LPL.
 - d. Or accepted equivalent product.

3. Vapor Retarder: 10 mil polyethylene sheet conforming to ASTM E1745.
- I. Curing Compound:
1. Liquid form, which will form impervious membrane over, exposed surface of concrete when applied to fresh concrete by means of spray gun. Use Type I, Class A or B, having 18 percent minimum solids conforming to ASTM C309.
 2. Products:
 - a. BASF Building Systems; Kure 1315.
 - b. Euclid Chemical Company; Super Diamond Clear VOX.
 - c. W. R. Meadows, Inc.; VOCOMP-30.
 - d. Dayton Superior Corp; Safe Cure and Seal 30 percent.
 - e. Or accepted equivalent product.
- J. Burlap Mats:
1. Conform to AASHTO M182.
- K. Sisal-Kraft Paper and Polyethylene Sheets for Curing:
1. Conform to ASTM C171.
- L. Non-shrink Grout:
1. Non-shrink grout shall be a high precision, fluid, extended working time grout. The minimum 28-day compressive strength shall be 7,500 psi, when mixed at a fluid consistency.
 2. Grout shall have an extended working time of 30 minutes minimum when mixed to a fluid consistency as defined in ASTM C827 at temperature extremes of 45 to 90 degrees F in accordance with ASTM C1107.
 3. Non-shrink grout shall meet the requirements of ASTM C1107; Grade B or C when tested using the amount of water needed to achieve fluid consistency per ASTM C939.
 4. The grout when tested shall not bleed or segregate at maximum allowed water.

5. Products:

- a. Master Builders, Inc.; Masterflow 928.
- b. The Euclid Chemical Co.; Hi Flow Grout.
- c. Sika Corp.; SikaGrout 212.
- d. Or acceptable equivalent product.

2.02. MIXES

- A. Conform to ASTM C94, except as modified by these specifications.
- B. Air content as determined by ASTM C231:
 - 1. 5 +/- 1-1/2 percent for concrete using 1-1/2 inch maximum aggregate size.
 - 2. 6 +/- 1-1/2 percent for concrete using 3/4-inch maximum aggregate size.
- C. Provide concrete with the following compressive strengths at 28 days and proportion it for strength and quality requirements in accordance with ACI 318. The resulting mix shall not conflict with limiting values specified in Table 1.

TABLE 1				
Class	Type of Work	28-Day Minimum Compressive Strength (psi)	Minimum Cementitious Content (lbs per C.Y.)	Maximum Water/ Cement Ratio
A	Concrete for all structures and concrete not otherwise specified.	4,500	560	0.42
B	Pavement, concrete topping	3,000	500	0.54
C	Concrete fill below structure foundations, Concrete topping, and miscellaneous unreinforced concrete.	2,000	376	0.60

- D. Measure slump in accordance with ASTM C143:

1. Proportion and produce the concrete to have a maximum slump of 4 inches. A tolerance of up to 1 inch above the indicated maximum is allowed for individual batches provided the average for all batches or the most recent 10 batches tested, whichever is fewer, does not exceed the maximum limit. Concrete of lower than usual slump may be used provided it is properly placed and consolidated.
2. Mixes containing water reducers shall have a maximum slump of 6 inches after the addition of a mid-range water reducer and maximum slump of 8 inches after the addition of a high range water reducer.

E. Pozzolan Content:

1. Fly ash shall not exceed 20 percent of the total cementitious content.

F. Aggregate Size:

1. Aggregate size shall be 3/4-inch maximum for slabs and sections 8 inches thick and less. Aggregate size shall be 1 inch maximum for sections greater than 8 inches and less than 17 inches. Aggregate size shall be 1-1/2 inches maximum for all slabs and sections greater than 17 inches.
2. Combined aggregate grading shall be as shown in the following table:

TABLE 2				
Maximum Aggregate Size	1-1/2 inch	1 inch	3/4-inch	3/8-inch
Aggregate Grade per ASTM C33	467	57	67	8

G. Fiber Reinforcement

1. Concrete shall contain 1.0 lb/CY synthetic fibers.
2. Synthetic fibers shall be MONO-TUF by ABC Polymers Industries, LLC or equal.

PART 3 - EXECUTION

3.01. INSPECTION

- A. Examine the subgrade and the conditions under which work is to be performed and notify the Engineer in writing of unsatisfactory conditions. Do not proceed with the

work until unsatisfactory conditions are corrected to comply with specified subgrade conditions in a manner acceptable to the Engineer.

3.02. MIXING AND TRANSPORTING CONCRETE

- A. General: Conform to concreting procedures set forth in ASTM C94, ACI 304R and as specified herein. Concrete shall be rejected if it does not meet these Specifications.
1. Transport concrete to discharge locations without altering the specified properties of water-cement ratio, slump, air entrainment, temperature and homogeneity.
 2. Discharge concrete into forms within 1-1/2 hours after cement has entered mixing drum or before the drum has revolved 300 revolutions after the addition of water, whichever occurs first.
 3. Do not add water at the jobsite unless permitted by the Engineer. If it is necessary to add water to obtain the specified slump, add water per ASTM C94, but do not exceed the maximum water content in the reviewed concrete design mix. Added water shall be incorporated by additional mixing of at least 35 revolutions.
 4. Do not add water to concrete containing high range water reducing admixture. Do not add water to concrete in delivery equipment not acceptable for mixing.
 5. Keep a record showing time and place of each pour of concrete, together with transit-mix delivery slips certifying the contents of the pour.
 6. Discharge of concrete shall be completed within the limits set out in Table 3.

TABLE 3			
Concrete Placement Limits			
Air Temperature (F)	Concrete Temperature Limits	Hydration Controlling Admixture Allowed	Time Limit for Completion of Placing After Initial Mixing
< 32°	60° - 75°	No	150 minutes
32° - 60°	40° - 60°	No	120 minutes
60° - 85°	85° Max	No	90 minutes
60° - 85°	85° Max	Yes	120 minutes

- B. Conveying: Convey concrete from agitator or mixer truck to place of final deposit in forms by one of the following methods:
1. Buckets or hoppers with discharge gates having a clear opening equal to not less than one-third the maximum interior horizontal area or five times the maximum aggregate size being used, whichever is greater, and side slopes of not less than 60 degrees to horizontal.
 2. Buggies or wheelbarrows equipped with pneumatic tires.
 3. Round bottom, metal or metal-lined chutes with inclined slope of between 2 to 3 feet horizontally to 1 foot vertically and of sufficient capacity to avoid overflow.
 4. Circular drop pipes with a top diameter of at least eight times the maximum aggregate size, but not less than 6 inches, or tapered to not less than six times maximum aggregate size.

3.03. CONCRETE ACCEPTANCE

- A. Accept or reject each batch of concrete delivered to the point of agitator or mixer truck discharge. Sign delivery batch tickets to indicate concrete acceptance.
- B. Reject concrete delivered without a complete concrete delivery batch ticket as specified herein. The concrete supplier will furnish copies of the signed batch ticket to the Contractor and Engineer.
- C. The Contractor's testing agency shall perform field tests at the point of placement. Accept or reject concrete on the basis of conformity with slump, air content and temperature specified.
- D. The testing agency shall inspect concrete transit truck's barrel revolution counter and gauge for measuring water added to the concrete. Reject concrete that exceeds the maximum barrel revolution of 300, the limits in Table 03 30 00-3 or concrete that has water content exceeding the specified water-cement ratio.
- E. Reject concrete not conforming to specification before discharging into the forms.

3.04. PREPARATION AND COORDINATION

- A. Contractor shall notify the Owner or Construction Manager of readiness to place concrete in any portion of the work a minimum of 5 working days prior to concrete

placement. Failure to provide this notification will be cause for delay in placing until observations can be completed.

- B. Coordinate the sequence of placement such that construction joints will occur only as designed.
- C. Schedule sufficient equipment for continuous concrete placing. Provide for backup equipment and procedures to be taken in case of an interruption in placing. Provide backup concrete vibrators at the project site. Test concrete vibrators the day before placing concrete.
- D. Compact the subgrade and/or bedding. Saturate the subgrade approximately eight hours before placement and sprinkle ahead of the placement of concrete in areas where vapor barrier is not used. Remove standing water, mud, and foreign matter before concrete is deposited.
- E. Where shown on the Contract Drawings, intentionally roughen surfaces of set concrete in a manner to expose bonded aggregate uniformly at joints.

3.05. CONCRETE PLACEMENT

- A. Placement shall conform to ACI 304R as modified by these specifications.
- B. Alternating sections of concrete walls and slabs may be cast simultaneously. Do not place adjacent sections of walls and slabs until seven days after placement of first placed concrete.
- C. Refer to the Drawings for additional requirements for concrete placements related to the individual structures associated with the Project.
- D. Do not place concrete until free water has been removed or has been diverted by pipes or other means and carried out of the forms, clear of the work. Do not deposit concrete underwater, and do not allow free water to rise on any concrete until the concrete has attained its initial set. Do not permit free or storm water to flow over surfaces of concrete so as to injure the quality or surface finish.
- E. Do not place concrete during inclement weather. Protect concrete placed from inclement weather. Keep sufficient protective covering ready at all times for this purpose.

- F. Deposit concrete at or near its final position to avoid segregation caused by rehandling or flowing. Do not deposit concrete in large quantities in one place to be worked along the forms with a vibrator.
- G. Deposit concrete continuously and in level layers 1 to 2 feet thick. Avoid inclined layers and cold joints. Place concrete at lower portion of slope first on sloping surfaces.
- H. Do not deposit partially hardened concrete in forms. Retempering of partially hardened concrete is not permitted. Remove partially hardened concrete from site at no additional compensation.
- I. Do not allow concrete to fall freely in forms to cause segregation (separation of coarse aggregate from mortar). Limit maximum free fall of concrete to 4 feet. Do not move concrete horizontally more than four feet from point of discharge. Space points of deposit not more than eight feet apart.
- J. At least two hours shall elapse after depositing concrete in the columns or walls before depositing in beams, girders, or slabs supported thereon. Place beams, girders, brackets, column capitals, and haunches monolithically as part of the floor or roof system, unless otherwise shown on the Contract Drawings.
- K. Consolidate concrete using mechanical vibrators operated within the mass of concrete and/or on the forms conforming to procedures set forth in ACI 309R and as specified herein.
- L. Conduct vibration to produce concrete of uniform texture and appearance, free of honeycombing, streaking, cold joints or visible lift lines.
- M. Conduct vibration in a systematic manner with regularly maintained vibrators. Furnish sufficient backup units at job site. Use vibrators having minimum frequency of 8,000 vibrations per minute and of sufficient amplitude to consolidate concrete. Use not less than one vibrator with crew for each 35 to 40 cubic yards of concrete placed per hour.
- N. Insert and withdraw vibrator vertically at a uniform spacing over the entire area of placement. Space distances between insertions such that spheres of influence of each insertion overlap.
- O. Use additional vibration with pencil vibrators on vertical surfaces and on exposed concrete to bring full surface of mortar against the forms so as to eliminate air voids,

bug holes and other surface defects. Employ the following additional procedures for vibrating concrete as necessary to maintain proper consolidation of concrete:

1. Reduce distance between internal vibration insertions and increase time for each insertion.
2. Insert vibrator as close to face of form as possible without contacting form or reinforcement.
3. Use spading as a supplement to vibration where particularly difficult conditions exist.

P. Pumping Concrete:

1. Conform to the recommendations of ACI 304.2R except as modified herein.
2. Base pump size on rate of concrete placement, length of delivery pipe or hose, aggregate size, mix proportions, vertical lift, and slump of concrete.
3. Use pipe with inside diameter of at least three times the maximum coarse aggregate size, but not less than 2 inches.
4. Do not use aluminum pipes for delivery of concrete to the forms.

Q. Waterstops:

1. Prevent displacement of waterstops during concrete placement.

3.06. CURING AND PROTECTION

A. General:

1. Protect concrete from premature drying, hot or cold temperatures, and mechanical injury, beginning immediately after placement and maintain concrete with minimal moisture loss at relatively constant temperature.
2. Comply with curing procedures set forth in ACI 301, ACI 308 and as specified herein.
3. Perform hot weather concreting in conformance with ACI 305R and as specified herein when the ambient atmospheric temperature is 80 degrees F or above.

4. Perform cold weather concreting in conformance with ACI 306R and when the ambient atmospheric temperature is below 40 degrees F.
5. Concrete required to be moist cured shall remain moist for the entire duration of the cure. Repeated wetting and drying cycles of the curing process will not be allowed.

B. Curing Duration:

1. Start initial curing after placing and finishing concrete as soon as free moisture has disappeared from unformed concrete surfaces. Initial curing starts as soon as concrete achieves final set. Forms left tightly in place are considered as part of the curing system; keep forms in place a minimum of 72 hours (3 days).
2. Begin final curing procedures immediately following initial curing and before the concrete has dried. Continue final curing for at least 7 days and in accordance with ACI 301 procedures for a total curing period, initial plus final, of at least 10 days.
3. Avoid rapid drying at the end of the final curing period
4. If protection is temporarily removed during the curing/protection period, the curing/protection period shall be extended by the amount of time lost (including time to bring concrete temperature back above 50° F).

C. Curing Requirements:

1. Unformed Surfaces: Cover and cure entire surface of newly placed concrete immediately after completing finishing operations and water film has evaporated from surface or as soon as marring of concrete will not occur. Protect finished slabs from direct rays of the sun to prevent checking, crazing and plastic shrinkage.
2. Formed Surfaces: Minimize moisture loss for formed surfaces exposed to heating by the sun by keeping forms wet until safely removed. Keep surface continuously wet by warm water spray or warm water saturated fabric immediately following form removal unless otherwise permitted by the Engineer.
3. Other concrete: Moist cure by moisture-retaining cover curing, or by the use of curing compound.

D. Curing Methods:

1. Water Curing: Use water curing for unformed surfaces. Continuously water cure all exposed concrete for the entire curing period. Provide moisture curing by any of the following methods:
 - a. Keeping the surface of the concrete continuously wet by ponding or immersion.
 - b. Continuous water-fog spray or sprinkling.
 - c. Covering the concrete surface with curing mats, thoroughly saturating the mats with water, and keeping the mats continuously wet with sprinklers or porous hoses. Place curing mats so as to provide coverage of the concrete surfaces and edges, with a 4 inch lap over adjacent mats. Weight down the curing cover to maintain contact with the concrete surface.
2. Sealing Materials:
 - a. Use common sealing materials such as plastic film or waterproofing (kraft) paper.
 - b. Lap adjacent sheets a minimum of 12 inch. Seal edges with waterproof tape or adhesive. Use sheets of sufficient length to cover sides of concrete member.
 - c. Place sheet materials only on moist concrete surfaces. Wet concrete surface with fine water spray if the surface appears dry before placing sheet material.
 - d. The presence of moisture on concrete surfaces at all times during the prescribed curing period is proof of acceptable curing using sheet material.
3. Membrane Curing Compound:
 - a. Apply membrane-curing compound uniformly over concrete surface by means of roller or spray at a rate recommended by the curing compound manufacturer, but not less than 1 gallon per 150 sq. ft. of surface area. Agitate curing material in supply container immediately before transfer to distributor and thoroughly agitate it during application for uniform consistency and dispersion of pigment

- b. Do not use curing compounds on construction and expansion joints or on surfaces to receive concrete fills and toppings or other applications requiring positive bond.
 - c. Reapply membrane-curing compound to concrete surfaces that have been subjected to wetting within 3 hours after curing compound has been applied by method for initial application.
 - E. Protection from environmental conditions: Maintain the concrete temperature above 50 degrees F continuously throughout the curing period (10 days). Make arrangements before concrete placing for heating, covering, insulation or housing to maintain the specified temperature and moisture conditions continuously for the curing period.
 - 1. When the atmospheric temperature is 80 degrees F and above, or during other climatic conditions which will cause too rapid drying of the concrete, make arrangements before the start of concrete placing for the installation of wind breaks or shading, and for fog spraying, wet sprinkling, or moisture-retaining covering.
 - 2. Protect the concrete continuously for the entire curing period (10 days).
 - 3. Maintain concrete temperature as uniformly as possible, and protect from rapid atmospheric temperature changes.
 - 4. Avoid temperature changes in concrete that exceed 5 degrees F in any one hour and 50 degrees F in any 24-hour period.
 - F. Protection from physical injury: Protect concrete from physical disturbances such as shock and vibration during curing period. Protect finished concrete surfaces from damage by construction equipment, materials, curing procedures and rain or running water. Do not load concrete in such a manner as to overstress concrete.
 - G. Protection from Deicing Agents: Do not apply deicing chemicals to concrete.
- 3.07. FIELD QUALITY CONTROL
- A. Hot Weather Requirements:
 - 1. During hot weather, give proper attention to ingredients, production methods, handling, placing, protection, and curing to prevent excessive concrete

temperatures or water evaporation in accordance with ACI 305R and the following.

2. When the weather is such that the temperature of the concrete as placed would exceed 90 degrees F, use ice or other means of cooling the concrete during mixing and transportation so that the temperature of the concrete as placed will not exceed 90 degrees F.
3. Take precautions when placing concrete during hot, dry weather to eliminate early setting of concrete. This includes protection of reinforcing from direct sunlight to prevent heating of reinforcing, placing concrete during cooler hours of the day, and the proper and timely application of specified curing methods.
4. There will be no additional reimbursement to the Contractor for costs incurred for placing concrete in hot weather.
5. Provide thermometers to indicate the ambient temperature and the temperature 2 inches inside the concrete surface. Thermometers, thermocouplers or other means of measurement, acceptable to the Engineer, which provide readings for concrete 2 inches below the surface, may be used. Concrete temperatures shall be recorded at the beginning and end of each work day and shall continue for the entire curing duration.

B. Cold Weather Requirements:

1. Provide adequate equipment for heating concrete materials and protecting concrete during freezing or near-freezing weather in accordance with ACI 306R and the following.
2. When the temperature of the surrounding atmosphere is 40 degrees F or is likely to fall below this temperature, use heated mixing water not to exceed 140 degrees F. Do not allow the heated water to come in contact with the cement before the cement is added to the batch.
3. When placed in the forms during cold weather, maintain concrete temperature at not less than 55 degrees F. Materials shall be free from ice, snow, and frozen lumps before entering the mixer.
4. Maintain the air and the forms in contact with the concrete at temperatures above 40 degrees F for the first five days after placing, and above 35 degrees F

for the remainder of the curing period. Provide thermometers to indicate the ambient temperature and the temperature 2 inches inside the concrete surface. Thermometers, thermocouplers or other means of measurement, acceptable to the Engineer, which provide readings for concrete 2 inches below the surface, may be used. Concrete temperatures shall be recorded at the beginning and end of each work day and shall continue for the entire curing duration.

5. Prior to concrete placement, the Contractor shall submit an example concrete temperature record to for review. Refer to ACI 306R-10, Section 4.4 for additional guidance regarding temperature records.
6. At the conclusion of each placement's curing period, a concrete temperature record shall be submitted to the Engineer for review. This complete record shall be provided to the Engineer by 10:00 AM the morning following the last recorded temperature.
7. There will be no additional reimbursement made to the Contractor for costs incurred for placing concrete during cold weather.

C. Backfill Against Walls:

1. Do not place backfill against walls until the concrete has obtained a compressive strength equal to the specified 28-day compressive strength unless otherwise approved in writing by the Engineer. Where backfill is to be placed on both sides of the wall, place the backfill uniformly on both sides.
2. Do not backfill the walls of structures that will be laterally restrained or supported by suspended slabs or slabs on grade until the slab is poured and the concrete has reached the specified compressive strength.
3. The Contractor may provide additional concrete testing at his expense to determine concrete strength.

D. Concrete Testing:

1. Concrete quality control testing will be performed on the concrete by an independent testing agency retained by the Contractor.
2. Testing Agency Responsibilities:

- a. Perform sampling and curing of test specimen in accordance with ASTM C31.
 - b. Take concrete samples at the point of placement to perform slump (per ASTM C143), air content (per ASTM C231), and temperature tests (per ASTM C1064) and for field control test specimens.
 - c. Testing agency personnel will record truck and load number from the delivery batch ticket, the concrete placement location of each specimen, the date, concrete strength, slump, air content, and temperature.
 - d. The testing agency will cast a minimum of one "set" of 6 test specimens, each 4 inch diameter by 8 inch long cylinders.
 - e. The required quantity of test specimen "sets" shall be that from the following criteria which yields the highest number of "sets".
 - (1) One set of specimens for each 50 cubic yards of each mix design of concrete.
 - (2) One set of specimens per placement.
 - (3) One set for each 5000 square feet of surface area for slabs or walls.
 - f. Test cylinders in accordance with ASTM C39. Test one cylinder at 7 days for information; test three cylinders at 28 days for acceptance; and hold one reserve cylinder for verification. Strength acceptance will be based on the average of the strengths of the three cylinders tested at 28 days. If one cylinder of a 28-day test manifests evidence of improper sampling, molding, or testing, other than low strength, discard it and use one of the reserve cylinder for the test result.
 - g. The testing agency shall submit test reports of concrete field measurements specified above to the Contractor and to the Engineer.
3. Contractor Responsibilities:
- a. Provide and maintain facilities for safe storage and proper curing of concrete test specimens on the project site, as required by ASTM C31.

- b. Cure/protect field cylinders in the same manner as the corresponding portion of the structure.
- 4. The Contractor may take additional test cylinders and tests to establish early concrete strength at no additional expense to the Owner.
- 5. Concrete acceptance shall be based on the requirements of ACI 318.
- 6. Field cured cylinders conforming to ASTM C31 will be required to determine field compressive strength of concrete. Laboratory cured cylinders for concrete quality testing shall not be used for determining field compressive strength.
- 7. Concrete Coring:
 - a. When the concrete quality test specimen compression tests fail to be in compliance with the Contract Documents or when the Engineer detects deficiencies in the concrete, the Contractor will take concrete cores at least 2 inches in diameter from the structure in conformance with ASTM C42 at locations determined by the Engineer.
 - b. Obtain at least three representative cores from each member or area of concrete that is considered potentially deficient.
 - c. Obtain additional cores to replace cores that show evidence of having been damaged subsequent to or during removal from the structure.
 - d. The Contractor shall submit cores to the Contractor's independent testing agency for completion of cylinder compression tests in conformance with ASTM C39. The independent testing agency shall submit test strength test results of cores specified above to the Contractor and to the Engineer.
 - e. All costs associated with coring and testing of cores will be borne by the Contractor at no additional cost to the Owner.
 - f. Concrete not meeting the requirements of the Contract Documents shall be removed and replaced. All additional costs for concrete removal and replacement shall be borne by the Contractor at no additional cost to the Owner.

END OF SECTION

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SECTION 03 35 00

CONCRETE FINISHES

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section describes materials and methods of concrete finishes for cast in place concrete.

1.02. REFERENCES

- A. American Concrete Institute (ACI):
 - 1. 301: Specifications for Structural Concrete.
 - 2. 302.1R: Construction of Concrete Floors.
 - 3. 311.4R: Guide for Concrete Inspection.

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.

1.04. QUALITY ASSURANCE

- A. Prior to concrete construction, develop an outlined quality control program for concrete finishing.

PART 2 - PRODUCTS

2.01. EPOXY BONDING COMPOUND

- A. See Section 03 30 00.

2.02. CONCRETE REPAIR MATERIAL

- A. Concrete repair material shall be in accordance with Section 03 01 30.

PART 3 - EXECUTION

3.01. CONCRETE FINISHES

- A. Finish concrete surfaces in accordance with the following schedule:

Table 1	
Finish Designation	Area Applied
F-1	Beams, columns, and exterior walls not exposed to water or view.
F-2	Exterior and interior walls, beams, and columns exposed to water, unless such items are to be coated.
F-3	Walls, beams, and columns of structures or buildings exposed to view and to 1 foot below water level or finished grade. Underside of formed floors or slabs. EXCEPTION: surfaces that are to be coated.
S-1	Slabs and floors to be covered with concrete or grout.
S-2	Slabs and floors of structures or buildings exposed to view or which are water bearing.
E-1	Exposed edges. EXCEPTION: edges normally covered with earth.
E-2	Top of walls, beams, and similar unformed surfaces.

1. Finish F-1: Repair defective concrete, fill depressions deeper than 1/2-inch, and fill tie holes.
2. Finish F-2: Repair defective concrete, remove fins, fill depressions 1/4-inch or deeper, and fill tie holes.
3. Finish F-3: In addition to Finish F-2, fill depressions and airholes with mortar. Dampen surfaces and then spread a slurry consisting of one part cement and one and one-half parts sand by damp loose volume, over the surface with clean

burlap pads or sponge rubber floats. Remove any surplus by scraping and then rubbing with clean burlap.

4. Finish S-1: Screed to grade without special finish unless otherwise shown on the Contract Documents. Roughen and/or apply bonding agent where shown on the Contract Drawings.
5. Finish S-2: Smooth steel trowel finish.
6. Finish E-1: Provide chamfer or beveled edges per Section 03 10 00.
7. Finish E-2: Strike smooth and float to an F-3 or F-4 finish.

- B. Protect finished concrete surfaces from damage by construction equipment, materials, curing procedures and rain or running water.

3.02. FINISHING FOR FORMED SURFACES

- A. Cure surfaces until finishing and repairing are completed.
- B. Perform finish work as soon as possible after forms are removed. Remove fins and irregularities by grinding or rubbing, fill depressions deeper than specified with mortar, and repair tie holes.
- C. Conform to the requirements specified in Section 03 10 00 for tolerances for formed surfaces.

3.03. FINISHING OF UNFORMED SURFACES

- A. Provide float finish then roughen the surface with stiff brushes or rakes before the final set for surfaces scheduled to receive concrete fills and toppings.
- B. Provide steel-trowel finish to all top, horizontal and inclined surfaces not otherwise specified or indicated. This includes concrete fills and toppings and floors. Provide hand steel-trowel finish to all surfaces such as weirs or walls over which liquids will flow.
- C. Provide broom finish to exterior walkways, exterior stairs, entrance platforms and loading docks.

3.04. CONCRETE REPAIR

A. Surface Defects:

1. Do not repair defects until concrete has been reviewed by the Engineer. Coordinate repair of concrete surfaces with Section 03 01 30.
2. Repair defects including, air voids and bug holes with a nominal diameter or depth greater than 1/4-inch, honeycombed areas, visible construction joints, fins, burrs, color and texture variations and other defects as determined by the Engineer. Make concrete repairs with a polymer modified cementitious repair mortar in accordance with Section 03 01 30 to produce a concrete surface uniform in color and texture and free of all irregularities.

B. Crack Repair:

1. Repair concrete cracks in accordance with Section 03 01 30.

C. Tie-hole Repair:

1. Repair tie holes in accordance with Section 03 10 00.

END OF SECTION

SECTION 03 40 00

PRECAST CONCRETE

PART 1 - GENERAL

1.01. REFERENCES

- A. The following is a list of standards which may be referenced in this section:
 - 1. American Concrete Institute (ACI): 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
 - 2. ASTM International (ASTM):
 - a. A36, Standard Specification for Structural Steel.
 - b. A416, Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
 - c. C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
 - 3. Precast/Prestressed Concrete Institute (PCI):
 - a. MNL-117, Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products.
 - b. MNL-120, Design Handbook for Precast and Prestressed Concrete, Third Edition.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Action Submittals:
 - 1. Sealer for Exterior Surfaces: Product data with mixing/application instructions.
 - 2. Calculations and Technical Data: Proposed details and design calculations for stresses in all critical sections of precast members for all loading conditions including transportation, handling, and erection.

C. Informational Submittals:

1. For Precast Manufacturers Not Listed in Article Quality Assurance:
 - a. Experience record on production of precast concrete as shown, with information on precast plant, that will indicate capability to satisfactorily perform the Work.
 - b. Evidence of current PCI plant certification.
2. Certificate of Compliance: Certify admixtures and concrete do not contain calcium chloride.
3. Test Reports:
 - a. For precast manufacturer's concrete test cylinders.
 - b. Inspection of installed panels.

1.03. QUALITY ASSURANCE

A. Qualifications of Precast Manufacturers:

1. Precast Concrete and Precast Prestressed Concrete: Product of manufacturer with 3 years' experience producing precast concrete products of quality specified.
2. Precast Plant: PCI certified plant with current certification.
3. Calculations stamped by an engineer registered in the State of Colorado.

PART 2 - PRODUCTS

2.01. MATERIALS

A. Formwork:

1. One-piece, full length and without seams.
2. As specified in Section 03 10 00.

B. Reinforcing Steel: As specified in Section 03 21 00.

C. Cement: As specified in Section 03 30 00.

- D. Aggregates: As specified in Section 03 30 00 for 3/4-inch maximum size.
- E. Admixtures: As specified in Section 03 30 00.
- F. Embedded Items: As shown on Drawings.
- G. Sealer for Exterior Surfaces:
 - 1. Silane Sealer: One-component penetrating sealer, hydrophilic (isopropyl alcohol as a carrier) with 40 percent active ingredients.
 - 2. Manufacturers:
 - a. Master Builders Co.
 - b. Euclid Chemical Co.
- H. Precast Concrete Members: Channel as shown on Drawings.

2.02. CONCRETE MIX

- A. Conform to ASTM C94, except as modified herein.
 - 1. 28-Day Minimum Compressive Strength – 5,000 psi
 - 2. Minimum Cementitious Content – 630 lbs/CY
 - 3. Maximum Water/Cement Ratio – 0.40

2.03. DESIGN REQUIREMENTS

- A. Structural Precast Members:
 - 1. Meet applicable sections of PCI MNL-120.
 - 2. Design for spans and superimposed live and dead loads shown plus dead loads of members.

2.04. FABRICATION

- A. General:
 - 1. Comply with PCI MNL-117.

2. Reinforcing Steel:
 - a. Place in position before concrete is cast.
 - b. Keep clean and free from form oil or other substances harmful to bond.
 3. Forms: Produce smooth surfaces.
 4. Concrete: Deposit, vibrate, finish, and cure in accordance with recommended practices of ACI 304R. Steam curing is permitted.
 5. Coordinate dimensions, determine type, quantity, size, and location of, and furnish necessary embedded items in precast concrete. Coordinate location of embedded items in cast-in-place concrete necessary to connect precast items.
- B. Surface Finish for Precast Structural Units: Furnish concrete finish, as specified in Section 03 30 00, to additional concrete field placed on precast units.
1. Other Surfaces: Smooth screeded finishes, unless otherwise shown.

2.05. SOURCE QUALITY CONTROL

- A. Prepare minimum three standard concrete test cylinders for each 50 cubic yards or fraction thereof of concrete placed in the precast work in accordance with ASTM C31.
- B. Test and record concrete strengths.

PART 3 - EXECUTION

3.01. ERECTION

- A. Verify that anchorage inserts are in correct locations.
- B. Handle and erect precast concrete with care as recommended by manufacturer.
- C. Erect precast units plumb, straight, level, square, and in proper alignment.
- D. Field Cutting: Not allowed.

3.02. PATCHING

- A. Mix and place patching mixture to match color and texture of surrounding concrete and to minimize shrinkage.
- B. Reference Section 03 30 00 for repair material and procedure.
- C. Demonstrate patching method and obtain acceptance and approval.

3.03. CLEANING

- A. After installation, clean soiled precast concrete surfaces with detergent and water, using fiber brush and sponge.
- B. Use acid solution only to clean particularly stubborn stains after more conservative methods have been tried unsuccessfully.
- C. Use extreme care to prevent damage to precast concrete surfaces and to adjacent materials.
- D. Rinse thoroughly with clean water immediately after using cleaner.

3.04. FIELD QUALITY CONTROL

- A. Inspection: Record location and condition of damaged panels.
- B. Resolution:
 - 1. Repair damage to satisfaction of Engineer and Owner.
 - 2. Remove panels with damage or repairs not acceptable to Engineer.
 - 3. Install new acceptable panels in place of those removed.
 - 4. Perform reinspection and obtain acceptance by Engineer.

3.05. PROTECTION

- A. Protect precast units from chipping, spalling, cracking, or other damage to the units after delivery to Site.

END OF SECTION

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SECTION 03 42 10

PRECAST CIRCULAR CONCRETE MANHOLES

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes design, materials, testing, and installation of precast circular concrete manholes.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's shop drawings, design calculations, and other required submittals in accordance with the submittal requirements in Section 03 40 00.
- C. Submit manufacturer's catalog data on precast concrete manholes, frames, covers, locking bolts, and steps. Show manhole dimensions and materials of construction by ASTM reference and grade. Show lettering on manhole covers.
- D. Submit manufacturer's product data and application and/or installation instructions for waterproofing and external sealing bands.
- E. Submit design calculations and certification for each precast concrete manhole, signed and sealed by a civil or structural engineer registered in the State of Colorado. The submittal shall include a statement certifying that each manhole's design and construction comply with the specified design load conditions and the referenced ASTM specifications.

PART 2 - MATERIALS

2.01. PRECAST CIRCULAR CONCRETE MANHOLES

- A. Precast circular concrete manholes shall comply with ASTM C478, except that the wall thickness shall be 8 inches minimum. Minimum clear cover shall be 2 inches. See Construction Drawings for manhole diameters.
- B. Design all manholes for HS-20 traffic loading.

- C. Manholes shall be designed to resist buoyancy by use of self-weight. Buoyancy and hydrostatic surcharge calculations shall be based upon the effects of the groundwater assuming groundwater is not more than 2-ft below the finished ground surface.
- D. Minimum allowable steel shall be hoops of No. 4 wire cast into each unit.
- E. Precast top sections shall be as shown on the Drawings.

2.02. PRECAST CONCRETE

- A. Refer to Section 03 40 00.

2.03. STEPS OR RUNGS

- A. Cast manholes with steps (ladder rungs). Steps (ladder rungs) shall be 1/2-inch minimum diameter steel reinforced bar with a polypropylene plastic covering (per ASTM D4101). Minimum clear length of rungs shall be 14 inches. Space rungs vertically at 12 inches on center, set between 5 and 6 inches from the face of the concrete, and align with each other in a straight vertical line (both parallel and perpendicular to ladder rungs). Steps shall be M.A. Industries Inc. #PS2-PF or approved equal.

2.04. MANHOLE FRAME AND COVER

- A. For the waterline, manhole covers shall have the word "WATER" cast thereon. Do not apply any other lettering.
- B. For the buried fiber optic manholes, manhole covers shall have the word "FIBER" cast thereon. Do not apply any other lettering.
- C. All manhole ring/covers shall be drilled and tapped by the Contractor with two (2) McGard Intimidator stainless steel manlocks (Part No. 127003, no substitutions), 180 degrees apart. Manlocks shall be installed per the manufacturer's recommendation. Contractor to coordinate with the Construction Manager prior to ordering manlocks to confirm that the correct Thornton proprietary locking bolts are being supplied.
- D. Frame and cover manufacturers:
 - 1. 24" reversible frame B-5086 by D&L Supply Company or approved equal.
 - 2. 24" cover A-1043 by D&L Supply Company or approved equal.

3. 24" reversible manhole assembly set V-1600-3 by East Jordan Iron Works or approved equal.
4. 30" reversible frame B-5490 by D&L Supply Company or approved equal.
5. 30" cover A-1361 by D&L Supply Company or approved equal.
6. 30" reversible manhole assembly set 1480 by East Jordan Iron Works or approved equal.

2.05. WATERPROOFING

- A. Provide high solids, cold applied liquid elastomeric waterproof membrane on the exterior of the manhole in accordance with ASM C836.
- B. Use primer as recommended by the manufacturer.
- C. Waterproof membrane shall be Conseal CS-1800 or equal.

2.06. EXTERNAL SEALING BANDS

- A. Provide butyl-rubber-based external sealing bands on all pre-cast manhole section joints in accordance with ASTM C877.
- B. External sealing bands shall be 9-inches wide, minimum.
- C. Use primer as recommended by the external sealing bands manufacturer.
- D. External sealing bands shall be Conseal CS-212, Press-Seal EX-WRAP, or approved equal.

2.07. SEALING COMPOUND AND MORTAR

- A. Butyl rubber sealing compound shall comply with ASTM C990. Joint sealant shall be ConSeal™ CS-202 or equal. Mortar shall comply with ASTM C387, Type S, or use grout complying with Section 03 30 00.

2.08. ROCK BASE

- A. Refer to Section 31 23 00.

PART 3 - EXECUTION

3.01. MANHOLE BASE

- A. Install rock base material per the Construction Drawings and Section 31 23 00.

3.02. SEALING AND GROUTING OF MANHOLE SECTIONS

- A. Clean ends of precast sections of foreign materials. Place two wraps of butyl rubber sealing compound around the groove of the lower section. Place a bed of grout in and completely around the groove of the lower section. Set next section in place. Fill remaining interior and exterior joint cavity completely with mortar of the proper consistency. Trowel interior and exterior surfaces smooth on tongue-and-groove joints. Wipe off any excess grout from the interior and exterior of the joints. Prevent mortar from drying out by applying curing compound or comparable method. Chip out and replace cracked or defective mortar. Completed manhole shall be rigid and watertight.

3.03. INSTALLING MANHOLES

- A. Set each manhole unit plumb on a bed of sealant or mortar to make a watertight joint at least 1/2 inch thick with the concrete base or with the preceding unit. Point the inside joint and wipe off excess sealant or mortar. Secure manhole frame to the grade ring with grout and cement mortar fillet. Backfill, compact, and replace pavement.
- B. Use butyl rubber manhole joint sealant to seal frame to riser.
- C. Assemble units so that the cover matches the elevations shown on the Drawings.

3.04. WATERPROOFING APPLICATION

- A. Apply the exterior waterproofing sealant per the manufacturer's recommendations.

3.05. INSTALLATION OF SEALING BANDS

- A. Install the external sealing bands per the manufacturer's recommendations.
- B. External sealing bands shall overlap a minimum of twice its width.

3.06. BACKFILL AROUND MANHOLES

- A. Backfill and compact around the manholes per Section 31 23 00.

END OF SECTION

SECTION 03 42 20

PRECAST REINFORCED CONCRETE VAULTS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes design, materials, testing, and installation of precast concrete vaults.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Manufacturer's shop drawings, design calculations, and other required submittals in accordance with the submittal requirements in Section 03 40 00.
- C. Manufacturer's catalog data on vaults, frames, covers, locking bolts, and ladder. Show vault dimensions; thicknesses of walls, floors, and top slabs; reinforcing steel. Submit construction materials by ASTM reference and grade. Show lettering on manhole covers.
- D. Manufacturer's product data and application and/or installation instructions for waterproofing and external sealing bands.
- E. Design calculations and certification for each precast concrete vault, signed and sealed by a civil or structural engineer registered in the State of Colorado. The submittal shall include a statement certifying that each vault's design and construction comply with the specified design load conditions and the referenced ASTM specifications.

PART 2 - MATERIALS

2.01. PRECAST CONCRETE VAULTS

- A. Precast concrete vaults shall comply with ASTM C858 except as modified herein.
- B. Design loads for vaults shall comply with ASTM C857, except as modified below:
 - 1. Traffic loads, unless otherwise stated, shall conform to ASTM C857, Load Designation A-16 per Table 1. Design all vaults for HS-20 traffic loading.
 - 2. As a minimum the following vault loading conditions shall be included in the vault design:

- a. Vault roof removed while structure is backfilled to grade and subject to live and dead loads.
 - b. Vault roof in place and walls subject to simultaneous vertical and horizontal application of all live, impact, groundwater or 100-year flood and dead loads. Include the case of an ASTM C857, A-16 designated load placed directly above the wall.
- 3. Design shall also comply with the following restrictions:
 - a. The maximum allowable reinforcement ratio is one-half the reinforcement ratio that would produce a balanced strain condition.
 - b. Include a live load surcharge of two (2) feet of soil in the design of the walls.
 - c. Vaults shall be designed to resist buoyancy by use of self-weight and backfill soils placed on the extension of the mat foundation beyond the exterior walls of the vault. Only the soil directly above this overhang is permitted to be included in the resisting dead load calculation.
 - d. Buoyancy and hydrostatic surcharge calculations shall be based upon the effects of the groundwater assuming groundwater is not more than 2-ft below the finished ground surface.
- C. Precast vault construction shall be in the form of monolithic walls or horizontal wall sections. Do not use panel walls.
- D. Minimum wall thickness shall be 8 inches. Minimum clear cover shall be 2 inches.
- E. Design and construct vaults to be watertight when subjected to groundwater over the entire height of the vault.
- F. Precast Concrete: Refer to Section 03 40 00.
- G. Coarse aggregate and sand: Refer to Section 03 30 00.
- H. Steel reinforcement: Refer to Section 03 21 00.
- I. For concrete admixtures, refer to Section 03 30 00.
- J. Water: Potable
- K. Butyl rubber-based sealants conforming to AASHTO M198, Type B with no bitumen content.

2.02. LADDER

- A. Refer to the Construction Drawings.

2.03. MANHOLE FRAME AND COVER

- A. For the waterline, manhole covers shall have the word "WATER" cast thereon. Do not apply any other lettering.
- B. For the buried fiber optic manholes, manhole covers shall have the word "FIBER" cast thereon. Do not apply any other lettering.
- C. Locking manhole ring and cover by East Jordan, drilled and tapped for locking bolts. Coordinate with Construction Manager for approved City locking bolt manufacturer.

2.04. ACCESS HATCHES

- A. Refer to Section 05 53 00.

2.05. WATERPROOFING

- A. Provide high solids, cold applied liquid elastomeric waterproof membrane on the exterior of the manhole in accordance with ASTM C836.
- B. Use primer as recommended by the manufacturer.
- C. Waterproof membrane shall be ConSeal CS-1800 or equal.

2.06. EXTERNAL SEALING BANDS

- A. Provide butyl-rubber-based external sealing bands on all pre-cast manhole section joints in accordance with ASTM C877.
- B. External sealing bands shall be 9-inches wide, minimum.
- C. Use primer as recommended by the external sealing bands manufacturer.
- D. External sealing bands shall be ConSeal CS-212, Press-Seal EX-WRAP, or approved equal.

2.07. SEALING COMPOUND AND MORTAR

- A. Butyl rubber sealing compound shall comply with ASTM C990. Joint sealant shall be ConSeal™ CS-202 or equal. Mortar shall comply with ASTM C387, Type S, or use grout complying with Section 03 30 00.

2.08. ROCK BASE

- A. Refer to Section 31 23 00.

2.09. FORGED LIFTING EYES

- A. Handling eyes and threaded inserts shall be galvanized steel. Tabs, plates, and other embedded items designed to provide load transfer at connections, shall be recessed in a pocket to receive mortar.

PART 3 - EXECUTION

3.01. VAULT BASE

- A. Install rock base material per the Construction Drawings and Section 31 23 00.

3.02. INSTALLING AND CONSTRUCTING VAULTS

- A. Set each precast concrete vault section plumb on a bed of sealant or mortar to make a watertight joint at least one-half (1/2) inch thick with the concrete base or with the preceding unit. Wipe off the excess mortar or sealant.

3.03. SEALING AND GROUTING

- A. Thoroughly clean foreign materials from the ends of precast sections. Fill joints between precast sections with either a butyl rubber sealing compound or mortar. Pockets at connections shall be firmly packed with mortar and struck flush with surface of concrete. Wipe off any excess grout from the interior and exterior of the joints.
 - 1. Prevent mortar from drying out by applying curing compound or other applicable method. Chip out and replace cracked or defective mortar.
 - 2. Joints shall prevent groundwater infiltration under full-height groundwater conditions.

3.04. WATERPROOFING APPLICATION

- A. Apply the exterior waterproofing sealant per the manufacturer's recommendations.

3.05. INSTALLATION OF EXTERNAL SEALING BANDS

- A. Install the external sealing bands per the manufacturer's recommendations.
- B. External sealing bands shall overlap a minimum of twice its width.

3.06. BACKFILL AROUND VAULTS

- A. Backfill and compact around the vaults per Section 31 23 00.

END OF SECTION

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SECTION 05 05 23

WELDING

PART 1 - GENERAL

1.01. REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
 - a. BPVC SEC V, Nondestructive Examination.
 - b. BPVC SEC IX, Welding and Brazing Qualifications.
2. American Society of Nondestructive Testing (ASNT): SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.
3. ASTM International (ASTM): A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
4. American Welding Society (AWS):
 - a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
 - b. A3.0, Standard Welding Terms and Definitions.
 - c. D1.1/D1.1M, Structural Welding Code - Steel.
 - d. D1.3/1.3M, Structural Welding Code - Sheet Steel.
 - e. D1.4/D1.4M, Structural Welding Code - Reinforcing Steel.
 - f. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
 - g. QC1, Standard for AWS Certification of Welding Inspectors.

1.02. DEFINITIONS

A. CJP: Complete Joint Penetration.

- B. CWI: Certified Welding Inspector.
- C. MT: Magnetic Particle Testing.
- D. NDE: Nondestructive Examination.
- E. NDT: Nondestructive Testing.
- F. PJP: Partial Joint Penetration.
- G. PQR: Procedure Qualification Record.
- H. PT: Liquid Penetrant Testing.
- I. RT: Radiographic Testing.
- J. UT: Ultrasonic Testing.
- K. VT: Visual Testing.
- L. WPQ: Welder/Welding Operator Performance Qualification.
- M. WPS: Welding Procedure Specification.

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Shop Drawings:
 - 1. Shop and field WPSs and PQRs.
 - 2. NDT procedure specifications prepared in accordance with ASME BPVC SEC V.
 - 3. Welding Data (Field): Submit welding data together with Shop Drawings as a complete package.
 - a. Show on Shop Drawings or a weld map complete information regarding base metal specification designation, location, type, size, and extent of welds with reference called out for WPS and NDE numbers in tails of combined welding and NDE symbols as indicated in AWS A2.4.

- b. Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for welds.
- c. Welding and NDE symbols shall be in accordance with AWS A2.4.
- d. Welding terms and definitions shall be in accordance with AWS A3.0.

C. Informational Submittals:

- 1. WPQs.
- 2. CWI credentials.
- 3. Testing agency personnel credentials.
- 4. CWI reports.
- 5. Welding Documentation: Submit on forms in referenced welding codes.

1.04. QUALIFICATIONS

- A. WPSs: In accordance with AWS D1.1/D1.1M (Annex M Forms) for field welding.
- B. WPQs: In accordance with AWS D1.1/D1.1M (Annex M Forms).
- C. CWI: Certified in accordance with AWS QC1 and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Owner or Construction Manager.
- D. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.

1.05. SEQUENCING AND SCHEDULING

- A. Unless otherwise specified, Submittals required in this section shall be submitted and approved prior to commencement of welding operations.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01. GENERAL

- A. Welding and Fabrication by Welding: Conform to governing welding codes referenced in attached Welding and Nondestructive Testing Table.

3.02. NONDESTRUCTIVE WELD TESTING REQUIREMENTS

A. Weld Inspection Criteria:

1. Selection of welds to be tested, unless 100 percent NDT is specified herein, shall be as agreed upon between Engineer and Contractor.
2. Unless otherwise specified, perform NDT of welds at a frequency as shown below and in the attached Table in accordance with referenced welding codes as follows. Perform UT on CJP groove welds that cannot be readily radiographed. In case there is a conflict, higher frequency level of NDT shall apply.
 - a. All other CJP Groove Welds: 10 percent random UT
 - b. Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.
 - c. All Welds: 100 percent VT.
3. Weld Acceptance:
 - a. VT:
 - (1) Structural Pipe and Tubing: AWS D1.1/D1.1M, Paragraph 6.9, Visual Inspection, Tubular Connections.
 - (2) All Other Structural Steel: AWS D1.1/D1.1M, Paragraph 6.9, Visual Inspection, Statically Loaded Nontubular Connections.
 - (3) UT: Perform on CJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.13.3, Class R Indications.
 - b. PT or MT:
 - (1) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.10.

(2) Acceptance shall be in accordance with VT standards specified above.

3.03. FIELD QUALITY CONTROL

A. CWI shall perform inspection, as necessary, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job material and proper storage.
2. Monitor conformance with approved WPS.
3. Monitor conformance of WPQ.
4. Inspect weld joint fit-up and perform in-process inspection.
5. Provide 100 percent visual inspection of all welds.
6. Supervise nondestructive testing personnel and evaluating test results.
7. Maintain records and prepare report confirming results of inspection and testing comply with the Work.

3.04. WELD DEFECT REPAIR

A. Repair and retest rejectable weld defects until sound weld metal has been deposited in accordance with appropriate welding codes.

3.05. SUPPLEMENTS

A. Welding and Nondestructive Testing Table:

Welding and Nondestructive Testing						
Specification Section	Governing Welding Codes or Standards	Submit WPS	Submit WPQ	Onsite CWI Req'd	Submit Written NDT Procedure Specifications	NDT Requirements
05 50 00 Metal Fabrications	AWS D1.1/D1.1M, Structural Welding Code—Steel or AWS D1.6/D1.6M, Structural Welding Code - Stainless Steel	Yes	Yes	Yes	No	100% VT; also see Section 05 50 00

END OF SECTION

SECTION 05 50 00

MISCELLANEOUS METAL

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes metal fabrications required for completion of work as shown on Contract Drawings and in accordance with Contract Documents.
- B. Furnish labor, materials, equipment, and incidentals necessary to install the products and items specified.

1.02. REFERENCES

- A. American Institute of Steel Construction (AISC):
 - 1. AISC Manual of Steel Construction, Thirteenth Edition.
- B. American Society for Testing and Materials (ASTM):
 - 1. A6: General Requirements for Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling.
 - 2. A36: Standard Specification for Carbon Structural Steel.
 - 3. A53: Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - 4. A108: Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
 - 5. A153: Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 6. A193/A193M: Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
 - 7. A194/A194M: Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
 - 8. A240: Standard Specification for heat-resisting chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels.
 - 9. A276: Standard Specification for Stainless Steel Bars and Shapes.

10. A325: Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength.
11. A500: Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
12. F436: Standard Specification for Hardened Steel Washers.
13. F593: Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
14. F594: Standard Specification for Stainless Steel Nuts.
15. F844: Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.
16. F1554: Standard Specification of Anchor Bolts, steel, 36, 55 and 105-ksi Yield Strength.

C. American Welding Society (AWS):

1. A2.4: Standard Symbols for Welding, Brazing, and Nondestructive Examination.
2. D1.1: Structural Welding Code.
3. D1.6: Structural Welding Code - Stainless Steel.

D. International Code Council – Evaluation Services (ICC-ES):

1. ICC-ES Acceptance Criteria 308: Post-installed Adhesive Anchors in Concrete Elements.

1.03. SUBMITTALS

A. Make submittals in accordance with the General Conditions and Section 01 33 00.

1. Submit shop drawings and product data showing materials of construction and details of installation for all items furnished under this Section. Shop drawings shall show sizes of members, method of assembly, anchorage and connection to other members.
2. Test Reports
 - a. Submit certified copies of mill test reports on each steel and stainless steel proposed for use showing the physical properties and chemical analysis.
3. Product Data

- a. Manufacturer's catalog sheets on pre-manufactured items.
- 4. Miscellaneous Submittals
 - a. Provide International Conference of Building Officials (ICBO) or other similar building code organization recommendations regarding safe allowable design loads for concrete anchors.

1.04. QUALITY ASSURANCE

A. Tolerances:

- 1. Maintain tolerances conforming Steel:
 - a. Conform to codes for arc and gas welding in building construction of AWS and to AISC Specifications.
 - b. Means and methods for maintaining tolerance requirements shall be included in the Quality Control Plan.
- 2. While being assembled, each item of the assembly shall be checked for dimensions, tolerances, accuracy of alignment workmanship and compliance to the approved drawings. Any deficiencies and deviations from the contract and/or approved drawings shall be corrected. All instruments and devices required during the inspection for the examination, measurement or testing of the assemblies shall be provided and calibrated by the manufacturer.

B. Steel:

- 1. Conform to codes for arc and gas welding in building construction of AWS and to AISC Specifications. Surfaces to be welded shall be free from loose scale, rust, grease, paint, and other foreign material, except mill scale that will withstand vigorous wire brushing may remain. Perform no welding when base metal is lower than 0 degrees F (-18 degrees C).
- 2. Qualify welding operators in accordance with AWS D1.1. Qualification tests shall be run by a recognized testing laboratory acceptable to the Engineer at Contractor's expense.

C. Stainless Steel:

- 1. Surfaces to be welded shall be free from foreign material. Perform no welding when base metal temperature is lower than 0 degrees °F.

2. Qualify welding operators in accordance with AWS D1.6. Qualification tests shall be run by a recognized testing laboratory acceptable to the Engineer at Contractor's expense.

D. Adhesive Anchors

1. Adhesive anchor installers shall be trained and certified by the anchor manufacturer.

1.05. DELIVERY, STORAGE, AND HANDLING

- A. Insofar as practical, shop factory-assemble items specified herein. Package, ship, and tag unassembled materials in a manner that will protect materials from damage and will facilitate identification and field assembly.
- B. Package stainless steel items in a manner to provide protection from contact with carbon steel.
- C. Protect painted coatings and finishes from damage due to metal banding and rough handling. Use padded slings and straps.
- D. Deliver items to be incorporated into the work of other trades in sufficient time to be checked prior to installation.
- E. Store fabricated items in a dry area, not in direct contact with ground.

1.06. FIELD MEASUREMENTS

- A. The Contractor shall verify all dimensions and shall make any field measurements necessary and shall be fully responsible for accuracy and layout of the work.
- B. The Contractor shall review the Contract Drawings and any discrepancies shall be reported to the Engineer for clarification prior to starting fabrication.

PART 2 - MATERIALS

2.01. MISCELLANEOUS METAL SHAPES, CASTINGS, BOLTS, AND ACCESSORIES

A. Structural Steel Shapes

1. L Shapes: ASTM A36
2. HSS Round Shapes: ASTM A500, Grade B, 42 ksi
3. Pipe Shapes: ASTM A53, Grade B, 35 ksi

4. Plates and Bars: ASTM A36.
- B. Stainless Steel Shapes
1. All Uses: AISI, Type 316
 2. For Welding: AISI, Type 316L
 3. Shapes and Bars: ASTM A276
 4. Plate, Sheet and Strip: ASTM A240.
- C. High Strength Bolts for Steel Members: ASTM A325.
- D. Steel Washers: ASTM F436.
- E. Plain Unhardened Steel Washers: ASTM F844.
- F. Carbon Steel Anchor Bolts
1. Headed bolts and threaded rods: ASTM F1554, Grade 36
 2. Nuts: ASTM A563, Hex, Grade A
 3. Washers: ASTM AF436, Type 1
 4. Hot-dip galvanized parts: ASTM A153, unless otherwise specified.
- G. Stainless Steel Anchor Bolts
1. Headed bolts: ASTM F593
 - a. Type 316, CW1 (5/8" to 3/4" dia)
 - b. Type 316, CW2 (>3/4" dia.)
 2. Threaded rods: ASTM A193
 - a. Type 316, Grade B8M, Class 1
 3. Nuts: ASTM F594, Hex, CW1 or CW2
 4. Washers: ASTM A240.
- H. Headed anchor studs Type H4L by Nelson Stud Welding, Inc., or approved equivalent.
1. Carbon or galvanized steel: ASTM A108

2. Stainless steel: ASTM A276, Type 316L

I. Galvanizing Hardware: ASTM A153, Zinc with a minimum 0.5% Nickel.

2.02. POST INSTALLED ANCHORS

A. Adhesive Anchors for installation in cast-in-place or precast concrete:

1. System Description:

- a. Adhesive anchors shall be a two part assembly of threaded rod with nuts and washers and an adhesive product as defined below.
- b. Refer to the Drawings for additional adhesive anchor requirements.
- c. Install adhesive anchors in full compliance with the adhesive manufacturer's recommendations.

2. Adhesive concrete anchors shall be valid for IBC use.

3. Adhesive Product:

- a. Hilti Corporation, HIT-RE 500 V3.
- b. Or Engineer approved equivalent product.

4. Threaded Rod, Washer(s), and Nut(s):

- a. The threaded rod, washer, and nut materials shall be as specified above.
- b. Refer to the drawings for location, spacing, and actual material type (carbon steel, galvanized steel, stainless steel, etc.) to be used for each application.

2.03. GRATING SUPPORT ANGLES AND FRAMING

A. Provide stainless steel support angles embedded in concrete. Angles shall be ¼-inch thick, inside depth of support angle shall equal depth of bearing bar, inside length of support angle leg shall equal depth of grating, but not less than 1¼. Provide one-inch by ¼-inch by eight inches long bent anchor bars or 3/8-inch diameter by six-inch headed anchor studs welded to backs of angles at 18 inches, on center.

2.04. STEEL BOLLARDS

A. Steel pipe bollards shall be fabricated to dimensions and details shown in Contract Drawings. Fabricate bollards from eight-inch nominal outside diameter pipe. Paint Color: Safety Yellow.

2.05. FABRICATION

A. Connections and Workmanship

1. Fabricate details and connection assemblies in accordance with Contract Drawings and Specifications, with projecting corners clipped and filler pieces welded flush.
2. Fit work together in fabrication shop and deliver complete or in parts, ready to be set in-place or assembled in field.
3. Provide work true to detail with clean, straight, sharply defined profiles and smooth surfaces of uniform color and texture free from defects impairing strength or durability.
4. Provide clips, lugs, brackets, straps, plates, bolts, nuts, washers, and similar items, as required for fabrication and erection.
5. Welding:
 - a. Provide rigid and continuous welds or spot-welded as specified and as shown on the Contract Drawings. Dress the face of welds flush and smooth. Close-fit exposed joints and locate where least conspicuous.
 - b. Weld shop connections and bolt or field weld connections, unless otherwise specified.
 - c. Grind exposed edges of welds to 1/8-inch minimum radius. Grind burrs, jagged edges, and surface defects smooth.
 - d. Prepare welds and adjacent areas so there is:
 - (1) No undercutting or reverse ridges on weld bead.
 - (2) No weld spatter on or adjacent to weld or other area to be painted or coated.
 - (3) No sharp peaks or ridges along weld bead.
6. Bolting:
 - a. Use bolts of lengths required so bolts do not project more than 1/4-inch beyond face of nut. Provide washers for stainless steel bolted connections. Do not use washers for carbon steel bolted connections unless noted otherwise. Provide hexagonal head bolts with hexagonal nuts.

- b. Provide holes required for connection of adjacent or adjoining work wherever noted on Drawings. Locate holes for bolting equipment to supports to tolerance of $\pm 1/16$ -inch of dimensions indicated.

PART 3 - EXECUTION

3.01. EXAMINATION

- A. Upon receipt of material at job site, inspect all materials for shipping damage. Replace damaged items at no cost to Owner.
- B. Examine supports for size, layout, and alignment.
- C. Correct defects considered detrimental to proper installation.

3.02. INSTALLATION

- A. Provide items such as bolts, shims, blocks, nuts, washers, and wedging pieces to complete installation.
- B. Erect to lines and levels, plumb and true, and in correct relation to adjoining Work. Secure parts using concealed connections when practicable.
- C. Plumb and true vertical members to tolerance of $\pm 1/8$ -inch in 10 feet. Level horizontal members to tolerance of $\pm 1/8$ -inch in 10 feet.
- D. Use steel bolts to connect structural steel members. Use stainless steel bolts to connect stainless steel and fiber reinforced plastic (FRP) members.
- E. Anchor Bolts and Concrete Anchors:
 - 1. Preset anchor bolts using templates. Do not use concrete anchors in place of anchor bolts.
 - 2. After anchor bolts are embedded, protect projecting threads by applying grease and having the nuts installed until the time of installation of equipment or metalwork.
 - 3. Do not install concrete anchors until concrete has reached specified minimum compressive strength.
 - 4. Install concrete anchors in accordance with anchor manufacturer recommendation. Embedment depth of anchor shall be as recommended by the anchor manufacturer, but not less than as shown on Contract Drawings.
 - 5. Locate concrete anchors to clear reinforcing bars in concrete.

- F. Weld headed anchor studs (HAS) in accordance with manufacturer's recommendations.
- G. Do not place new holes or enlarge unfair holes by use of cutting torch.

3.03. PAINTING, REPAIR, AND PROTECTION

- A. Apply an anti-seize compound on all stainless steel fasteners to prevent galling.
- B. Paint exposed carbon steel using System No. 10 per Section 09 90 00.
- C. Field repair of damaged primer.
 - 1. Touch up abrasions in the shop primer immediately after erection. Paint areas left unprimed for welding with primer after welding.

3.04. FIELD QUALITY CONTROL

- A. Contractor shall notify the Owner or Construction Manager of readiness for items under this Section to be inspected a minimum of five working days prior to the items being covered by further work. Failure to provide this notification will be cause for delay in placing until observations can be completed.

END OF SECTION

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SECTION 05 53 00

ACCESS HATCHES

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section describes materials, fabrication, and installation of aluminum access hatches.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit drawings of access hatches. Show dimensions and reference materials of construction by ASTM designation and grade. Show design criteria.
- C. Submit placing or erection drawings that indicate locations of fabricated items. Reproductions of contract documents will not be accepted for this purpose.

PART 2 - MATERIALS

2.01. ALUMINUM ACCESS HATCHES

- A. Access hatches shall be aluminum and of the size and configuration shown in the drawings.
- B. Access hatches shall be single leaf rated for H-20 loading and have a channel frame with drainage coupling. All hatch components; including hinges, latch, lifting mechanism assemblies, hold-open arms and guides, and brackets, pins, and fasteners shall be stainless steel.
- C. Hatch shall be engineered with lift assistance for smooth, easy one-hand operation. Manufacturer shall provide automatic hold-open arm with a grip handle release for lift assistance mechanism.
- D. Locking and Latching Devices: Manufacturer shall provide hatches with a watertight slamlock with recessed packlock (oversided) for locking mechanism.
- E. Access hatch leaf shall have a standard mill finish with diamond pattern. Aluminum in contact with dissimilar metals or concrete shall be coated with the manufacturer's standard bituminous coating.
- F. Manufacturers:

1. Bilco JAL-H20
2. Halliday Series H1C
3. USF Fabrication THS
4. Or approved equal.

2.02. WELDING ELECTRODES

- A. Welding for stainless steel shall conform to AWS D1.6: Structural Welding Code - Stainless Steel.
- B. Welding electrodes for aluminum shall be ER4043 filler metal.

PART 3 - EXECUTION

3.01. STORAGE OF MATERIALS

- A. Store structural material, either plain or fabricated, above ground on platforms, skids, or other supports. Keep material free from dirt, grease, and other foreign matter and protect from corrosion.

3.02. INSTALLATION AND ERECTION

- A. Clean the surfaces of metalwork to be in contact with concrete of rust, dirt, grease, and other foreign substances before placing concrete.
- B. Set hatch frames accurately in position when concrete is placed and support it rigidly to prevent displacement or undue vibration during or after the placement of concrete. Unless otherwise specified, where metalwork is to be installed in recesses in formed concrete, said recesses shall be made, metalwork installed, and recesses filled with dry-pack mortar in conformance with Section 03 30 00.
- C. Set frames for hatches so that the hatch will be flush with the slab.
- D. On vault roof slabs, route hatch drain, as necessary, through the slab so it terminates at the edge of the slab and can discharge outside outside the vault.

3.03. WELDING

- A. Perform welding on stainless steel per AWS D1.6: Structural Welding Code – Stainless Steel.
- B. Perform welding on aluminum by the gas metal arc (TIG) process. Welds shall be full penetration and smooth.

- C. Provide a minimum of two passes for metal in excess of 5/16-inch thickness.
- D. Produce weld uniform in width and size throughout its length with each layer of weldment smooth; free of slag, cracks, pinholes, and undercuttings; and completely fused to the adjacent weld beads and base metal. Avoid irregular surface, nonuniform bead pattern, and high crown. Form fillet welds of the indicated size of uniform height and fully penetrating. Accomplish repair, chipping, and grinding of welds in manner that will not gouge, groove, or reduce the base metal thickness.

END OF SECTION

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SECTION 06 60 20

FIBERGLASS REINFORCED PLASTIC (FRP) LADDERS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section describes materials, fabrication, and installation of vertical fiberglass reinforced plastic (FRP) ladders and for vertical climbing safety systems.
- B. Furnish all labor, materials, equipment and incidentals governed by this section necessary to install the fiberglass reinforced polymer (FRP) ladder products and vertical climbing safety system products as specified herein.

1.02. REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. D495: High Voltage, Low-Current, Dry Arc Resistance of Solid Electrical Insulation.
 - 2. D638: Tensile Properties of Plastics.
 - 3. D696: Coefficient of Linear Thermal Expansion for Plastics.
 - 4. D790: Flexural Properties of Unreinforced and Reinforced Plastics.
 - 5. D2344: Apparent Interlaminar Shear Strength of Parallel Fiber Composites by Short Beam Method.
 - 6. E84: Surface Burning Characteristics of Building Materials.
- B. Occupational Health and Safety Administration (OSHA):
 - 1. Code of Federal Regulations (CFR), Title 29, Section 1910.27

1.03. DESIGN CRITERIA

- A. Vertical Ladders: OSHA, IBC.
- B. Vertical ladders shall be designed to withstand a minimum of two loads of 250 pounds each, concentrated between any two consecutive attachments. The number and spacing of additional loads shall be in accordance with the anticipated usage of the ladder. Individual steps or rungs shall be designed to support a load of 250 pounds applied at any point.

1.04. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. The Contractor shall submit shop drawings of all fabricated vertical ladders and accessories.
- C. The Contractor shall furnish manufacturer's shop drawings clearly showing material sizes, types, styles, part or catalog numbers, complete details for the fabrication of and erection of components including, but not limited to, location, lengths, type and sizes of fasteners, clip angles, member sizes, and connection details.
- D. The Contractor shall submit the manufacturer's published literature including structural design data, structural properties data, corrosion resistance tables, certificates of compliance, test reports as applicable, and design calculations for systems not sized or designed in the Contract Documents.
- E. The Contractor may be required to submit sample pieces of each item specified herein for acceptance by the Engineer as to quality and color. Sample pieces shall be manufactured by the method to be used in the Work.
- F. Contractor shall submit manufacturer's shop drawings and material specifications for vertical climbing safety systems.

1.05. FIELD MEASUREMENTS

- A. Verify dimensions and make any field measurements necessary and be fully responsible for accuracy and layout of the work.
- B. Review the Drawings and report any discrepancies to the Engineer for clarification prior to starting fabrication.

1.06. QUALITY CONTROL / QUALITY ASSURANCE

- A. All items to be provided under this Section shall be furnished only by manufacturers having a minimum of ten (10) years' experience in the design and manufacture of similar products and systems. Additionally, if requested, a record of at least five (5) previous, separate, similar, successful installations in the last five (5) years shall be provided.
- B. Substitution of any component or modification of system shall be made only when approved by the Engineer.
- C. In addition to requirements of these specifications, comply with manufacturer's instructions and recommendations for work.

PART 2 - MATERIALS

2.01. GENERAL

- A. Vertical ladders shall be as manufactured by Fibergrate; Strongwell; or approved equal.
- B. All ladder materials are to be FRP structural shapes manufactured by the pultrusion process. All structural shapes shall be composed of fiberglass reinforcement and resin in qualities, quantities, properties, arrangements and dimensions as necessary to meet the design requirements and dimensions as specified in the Contract Documents.
- C. Fiberglass reinforcement shall be a combination of continuous roving, continuous strand mat, bi-directional roving mat and surfacing veil in sufficient quantities as needed by the application and/or physical properties required.
- D. Resins shall be fire retardant with chemical formulation necessary to provide the corrosion resistance, strength and other physical properties as required.
- E. All finished surfaces of FRP items and fabrications shall be smooth, resin-rich, free of voids and without dry spots, cracks, crazes or unreinforced areas. All glass fibers shall be well covered with resin to protect against their exposure due to wear or weathering.
- F. All pultruded ladder components shall be further protected from ultraviolet (UV) attack with 1) integral UV inhibitors in the resin and 2) a synthetic surfacing veil to help produce a resin rich surface, and 3) an appropriate UV resistant coating for outdoor exposures.
- G. All FRP products shall have a tested flame spread rating of 25 or less per ASTM E84 Tunnel Test.
- H. All ladder components shall be a color selected by Owner based on manufacturer's standard colors.
- I. Pultruded structural shapes used in the ladder system are to have the minimum longitudinal mechanical properties listed below:

Property	ASTM Method	Value
Tensile Strength	D638	30,000 psi
Tensile Modulus	D638	2.5 x 10 ⁶ psi
Flexural Strength	D790	30,000 psi
Flexural Modulus	D790	1.8 x 10 ⁶ psi
Flexural Modulus (Full Section)	N/A	2.8 x 10 ⁶ psi
Short Beam Shear (Transverse)	D2344	4,500 psi
Shear Modulus (Transverse)	N/A	4.5 x 10 ⁵ psi
Coefficient of Thermal Expansion	D696	8.0 x 10 ⁻⁶ in/in/°F
Flame Spread	E84	25 or less

- J. All fasteners used in the ladder system are to be Type 316 stainless steel.

2.02. VERTICAL LADDERS

- A. Fabricate vertical ladders as shown in the Drawings.
- B. The ladder side rail shall be 1-3/4" square tube with a wall thickness of 1/4" or greater. The rungs shall be 1-1/4" diameter pultruded structural shapes, continuously fluted to provide a non-slip surface. Rungs that are gritted as a secondary operation shall not be permitted.
- C. The distance between rungs, cleats, and steps shall not exceed 12 inches and shall be uniform throughout the length of the ladder. The minimum clear length of rungs or cleats shall be 16 inches.
- D. Ladder wall and floor mount shall be fabricated from stainless steel angles, 1/4" minimum thickness.
- E. All rungs shall be both mechanically attached to the ladder with stainless steel rivets and chemically bonded with epoxy.
- F. Provide a stainless-steel Ladder Up Safety Post by Bilco (LU-3) or approved equal for vertical ladders at access hatches.

2.03. VERTICAL CLIMBING SAFETY SYSTEM

- A. Vertical climbing safety system shall be compatible for installation on the ladders and be rung mounted.

- B. Vertical climbing safety system fabrication shall be stainless steel with stainless steel hardware and be supplied with a 3/8" minimum cable and connecting accessories.
- C. Vertical climbing safety system shall include a four (4) foot telescoping climbing extension that locks when fully extended.
- D. Minimum vertical climbing safety system specifications are as follows:

Minimum Break Strength	3,600 lbs
Single Point Anchor Rating	3,600 lbs
Maximum Number of Users	2

- E. Manufacturers:
 - 1. 3M™ DBI-SALA® Lad-Saf™ Cable Vertical Climbing Safety System
 - 2. Or approved equal.

PART 3 - EXECUTION

3.01. STORAGE OF MATERIALS

- A. All materials and equipment necessary for the fabrication and installation FRP ladders and appurtenances shall be stored before, during, and after shipment in a manner to prevent cracking, twisting, bending, breaking, chipping or damage of any kind to the materials or equipment, including damage due to over exposure to the sun. Any material which, in the opinion of the Owner, has become damaged as to be unfit for use shall be promptly removed from the site of work, and the Contractor shall receive no compensation for the damaged material or its removal.

3.02. FABRICATION

- A. All ladders shall be designed and laid out in strict accordance with OSHA 1910.27.
- B. All rungs shall penetrate the wall of the tube side rails and shall be connected to the rails with both epoxy and rivets to provide both a chemical and mechanical lock, respectively.
- C. Ladders shall be fully shop assembled.
- D. All cut or machined edges, holes and notches shall be sealed to provide maximum corrosion resistance. All field fabricated cuts shall be coated similarly by the contractor in accordance with the manufacturer's instructions.

3.03. INSTALLING LADDERS

- A. Install ladders to provide clearance in back of ladder so that the distance from the centerline of rungs, cleats, or steps to the nearest permanent object in back of the ladder shall be not less than 7 inches.
- B. Installing anchors bolts. See Section 05 50 00.

3.04. INSTALLING VERTICAL CLIMBING SAFETY SYSTEMS

- A. Install per manufacturer's recommendations.

END OF SECTION

SECTION 07 92 00

ARCHITECTURAL CAULKING AND SEALANTS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials and installation of architectural caulking and sealants for waterproofing buildings and structures.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's catalog data and descriptive literature.

PART 2 - PRODUCTS

2.01. CAULKING AND SEALANT COMPOUNDS

- A. Caulking shall be paintable.
- B. Exterior Applications: One-part, non-sag, moisture-curing polyurethane joint sealant conforming to ASTM C 920, Type S, Grade NS, Class 25. Use Pecora Corporation "Dynatrol I", Bostik's "Chem-Caulk 900," Sonneborn's "Sonolastic NP-1," or equal. Color of caulking and sealant shall match color of adjacent work.
- C. Interior Applications: Butyl-based compound, smooth-flowing, single component, architectural grade, synthetic, general purpose caulking compound, composed of 80% to 100% solids, butyl, non-oily, nonhardening, curing to a tack-free surface, paintable, in gun grade consistency. Use "DAP Butyl-Flex Caulking Compound," A.C. Horn's Vulcatex" Elastic Caulking Compound, acrylic latex Pecora Sealants AC-20, or equal. Color of caulking and sealants shall match color of adjacent work.
- D. Roof Applications: Butyl-based elastomeric tape sealant composed of 100% solids. Use GSSI "MB-10A Sealant Tape", or equal.

2.02. MASTIC

- A. Mastic shall be the general purpose butyl-based caulking compound specified, except that it shall be knife or trowel consistency. Mastic used the purpose of sealing metal roof end laps shall be butyl-based elastomeric tape sealant. Exterior applications exposed to weather shall be the polyurethane sealant hereinbefore specified in knife or trowel consistency.

2.03. PRIMERS

- A. Primers shall be quick-drying, colorless, nonstaining sealer of type and consistency as recommended by the manufacturer of the caulking material for the particular surfaces to be caulked or sealed.

2.04. PACKING

- A. Sealant backup or packing and packing for caulking compounds shall be nonstaining resilient material, such as glass fiber roving, neoprene, butyl, polyurethane, or other closed-cell foams, compatible with the caulking compound used.

PART 3 - EXECUTION

3.01. SURFACE PREPARATION

- A. Clean joints and spaces of dirt, dust, mortar, oil, and other foreign materials that might adversely affect the caulking work. Degrease with solvent or commercial degreasing agent. Surfaces shall be thoroughly dry before application of caulking compounds.
- B. If recommended by manufacturer, remove paint or other protective coating from surfaces to be caulked prior to priming and caulking application.
- C. Enclose joints on three sides. Where grooves for adequate caulking have not been provided, clean out grooves to the depth required or as indicated in drawings and grind to a minimum width of 1/4-inch without damage to the adjoining work. Do not grind on metal surfaces.
- D. Preparation of surfaces to receive caulking compound shall conform to the caulking manufacturer's specifications. Use air pressure or other methods approved by the manufacturer to achieve required results. Use masking tape to keep caulking compound off surfaces that will be exposed in the finished work.

3.02. LOCATIONS

- A. Exterior: Caulk and seal around architectural openings in exterior walls and roofs of buildings and structures, including penetrations for piping; conduits; ductwork; window, door, and louver frames; vents; and other locations shown in the drawings or required for waterproofing the building and structure.

3.03. PRIMING

- A. Prime concrete and other porous surfaces and any other surfaces recommended by the manufacturer, before applying caulking and sealants. Apply primer with a brush that will reach all parts of joints to be filled with caulking compound.

3.04. PACKING

- A. Fill joints and spaces deeper than 1/2-inch with packing to within 1/2-inch of the surface. Then fill the joints with caulking compound. Provide a minimum of 3/8-inch of caulking compound in all joints 1/2-inch in depth or deeper.

3.05. CAULKING AND SEALANT COMPOUNDS

- A. Store caulking and sealants at temperatures below 50°F. Do not use compounds when they become too jelled to be discharged in a continuous flow from the gun. Do not modify compounds by addition of liquids, solvents, or powders.

3.06. WORKMANSHIP

- A. Fill voids and joints solid. In caulking around openings, include entire perimeter of each opening, unless shown or specified otherwise. Use hand tools where the use of a gun is impracticable.

3.07. FINISHING

- A. Point caulked and sealed joints on flush surfaces with beading tool and internal corners with eaving tool. Remove excess material. Exposed caulking shall be free of wrinkles and uniformly smooth. Caulking and sealing shall be complete before final coats of paint are applied.

3.08. CLEANING

- A. Clean surfaces of materials adjoining caulked and sealed joints of any smears of compound or other soiling due to caulking application.

3.09. MISCELLANEOUS CAULKING AND SEALING WORK

- A. Provide caulking wherever required to prevent light leakage as well as moisture leakage.

END OF SECTION

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SECTION 09 90 00

PAINTING AND COATING

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials and application of painting and coating systems for the following surfaces:

1. Submerged metal.
2. Exposed metal.
3. Buried metal.

1.02. SUBMITTALS

Make submittals in accordance with the General Conditions and Section 01 33 00.

- A. Submit manufacturer's data sheets showing the following information:

1. Percent solids by volume.
2. Minimum and maximum recommended dry-film thickness per coat for prime, intermediate, and finish coats.
3. Recommended surface preparation.
4. Recommended thinners.
5. Statement verifying that the specified prime coat is recommended by the manufacturer for use with the specified intermediate and finish coats.
6. Application instructions including recommended equipment and temperature limitations.
7. Curing requirements and instructions.

- B. Submit color swatches.

- C. Submit certificate identifying the type and gradation of abrasives used for surface preparation.
- D. Submit material safety data sheets for each coating.

PART 2 - MATERIALS

2.01. PAINTING AND COATING SYSTEMS INDEX

- A. The following index lists the various painting and coating systems by service and generic type:

System No.	Title	Generic Coating
Submerged Metal Coating Systems		
7	Submerged Metal, Potable or Nonpotable Water	Epoxy
Exposed Metal Coating Systems		
10	Exposed Metal, Corrosive Environment	High-build epoxy (two-coat system) with polyurethane topcoat
18	Exposed Metal, Organic Zinc Primer for Shop Coating and Field Touch-Up	Organic zinc
Buried Metal Coating Systems		
21	Buried Metal	Epoxy
24	Buried Metal	Corrosion-resisting grease

- B. These systems are specified in detail in the following paragraphs. For each coating, the required surface preparation, prime coat, intermediate coat (if required), topcoat, and coating thicknesses are described. Mil thicknesses shown are minimum dry-film thicknesses.

2.02. SUBMERGED METAL COATING SYSTEMS

A. System No. 7--Submerged Metal, Potable or Nonpotable Water:

1. Type: Epoxy.
2. Service Conditions: For use with structures, valves, piping, or equipment immersed in potable or nonpotable water.
3. Surface Preparation: SSPC SP-10.
4. Coating System: Apply the manufacturer's recommended number of coats to attain the specified minimum coating thickness. Products: Devoe Bar-Rust 233H, Tnemec N140 or 100, Sherwin-Williams Tank Clad HS B62-80, PPG AQUAPON® LT NSF Low Temperature Epoxy Coatings 95-172, Carboline Carboguard 891, Ameron 395, International Interline 785HS, Keysite 740, or approved equal; 16 mils total. Color of topcoat: white. Each coat shall be different color than the one preceding it.

2.03. EXPOSED METAL COATING SYSTEMS

A. System No. 10--Exposed Metal, Corrosive Environment:

1. Type: High-build epoxy intermediate coat having a minimum volume solids of 60%, with an inorganic zinc prime coat and a pigmented polyurethane finish coat having a minimum volume solids of 52%.
2. Service Conditions: For use with metal structures or pipes subjected to water condensation; chemical fumes, such as hydrogen sulfide; salt spray; and chemical contact.
3. Surface Preparation: SSPC SP-10.
4. Prime Coat: Self-curing, two-component inorganic zinc-rich coating recommended by the manufacturer for overcoating with a high-build epoxy finish coat. Minimum zinc content shall be 12 pounds per gallon. Apply to a thickness of 3 mils. Products: Tnemec 90E-92, Devoe Catha-Coat 304 or 304V, International Interzinc 22HS, Ameron 9HS, Sherwin-Williams Zinc-Clad II Plus, PPG METALHIDE® 28 Inorganic Zinc-Rich Primer 97-672, or approved equal.

5. Intermediate Coat: Tnemec 104, ICI Devoe Devran 224HS or 231, International Interseal 670HS, Ameron 385, Carboline Carboguard 890, Sherwin-Williams Macropoxy 646 B58-600, PPG PITT-GUARD® Direct-to-Rust Epoxy Mastic Coating 97-145 series, or approved equal; 5 mils.
6. Finish Coat: Two-component pigmented acrylic or aliphatic polyurethane recommended by the manufacturer for overcoating a high-build epoxy coating. Apply to a thickness of at least 2 mils. Products: Tnemec Series 1075, ICI Devoe Devthane 379, International Interline 990HS, Ameron 450HS, Sherwin-Williams Hi-Solids Polyurethane B65-300, PPG PITTHANE® Ultra Gloss Urethane Enamel 95-812 series, or approved equal.

B. System No. 18--Organic Zinc Primer for Shop Coating and Field Touch-Up:

1. Type: Organic zinc primer having a minimum zinc content of 14 pounds per gallon.
2. Service Conditions: For use as a shop-applied primer or field touch-up primer over inorganic zinc prime coatings on exposed metal.
3. Surface Preparation: SSPC SP-10.
4. Coating: Coating shall be of the two- or three-component converted epoxy, epoxy phenolic, or urethane type. Products: Tnemec 90-97, International Interzinc 308, Ameron 68HS, ICI Devoe 313, Carboline 859, Sherwin-Williams Zinc-Clad III HS, PPG DURETHANE™ MCZ 97-679, or approved equal; applied to a minimum dry-film thickness of 3 mils. Organic zinc primer shall be manufactured by the prime coat manufacturer.

2.04. BURIED METAL COATING SYSTEMS

A. System No. 21--Buried Metal:

1. Type: High solids epoxy or phenolic epoxy having a minimum volume solids of 80% (ASTM D2697).
2. Service Conditions: Buried metal, such as valves, flanges, bolts, nuts, structural steel, and fittings.
3. Surface Preparation: SSPC SP-10.

4. Coating System: Apply three or more coats of Ameron 400, Tnemec 104HS or 80, ICI Devoe Bar-Rust 233H, Carboline 890LT, Sherwin-Williams Tank Clad HS B62-80 series, or approved equal; 30 mils total. Maximum thickness of an individual coating shall not exceed the manufacturer's recommendation.

B. System No. 24--Buried Metal:

1. Type: Corrosion-resisting grease.
2. Service Conditions: Buried metal, such as bolts, bolt threads, tie rods, and nuts.
3. Surface Preparation: SSPC SP-3 or SP-6.
4. Coating: NO-OX-ID GG-2 as manufactured by Sanchem, Inc. Apply to a minimum thickness of 1/4 inch.

2.05. ABRASIVES FOR SURFACE PREPARATION

A. Abrasives used for preparation of ferrous (excluding stainless steel) surfaces shall be one of the following:

1. 16 to 30 or 16 to 40 mesh silica sand or mineral grit.
2. 20 to 40 mesh garnet.
3. Crushed iron slag, 100% retained on No. 80 mesh.
4. SAE Grade G-40 or G-50 iron or steel grit.

B. Abrasives used for preparation of stainless steel surfaces shall be 20 to 40 mesh silicon carbide or aluminum oxide.

C. Abrasives used for preparation of copper and aluminum surfaces shall be one of the following:

1. Crushed slag, 80 to 100 mesh.
2. Very fine silica sand, 80 to 100 mesh.

D. Abrasives used for preparation of concrete and masonry surfaces shall be 16 to 30 or 16 to 40 mesh silica sand.

- E. In the above gradations, 100% of the material shall pass through the first stated sieve size and 100% shall be retained on the second stated sieve size.

PART 3 - EXECUTION

3.01. WEATHER CONDITIONS

- A. Do not paint in the rain, wind, snow, mist, and fog or when steel or metal surface temperatures are less than 5°F above the dew point.
- B. Do not apply paint when the relative humidity is above 85%.
- C. Do not paint when temperature of metal to be painted is above 120°F.
- D. Do not apply alkyd, inorganic zinc, silicone aluminum, or silicone acrylic paints if air or surface temperature is below 40°F or expected to be below 40°F within 24 hours.
- E. Do not apply epoxy, acrylic latex, and polyurethane paints on an exterior or interior surface if air or surface temperature is below 60°F or expected to drop below 60°F in 24 hours.

3.02. SURFACE PREPARATION PROCEDURES

- A. Remove oil and grease from metal surfaces in accordance with SSPC SP-1. Use clean cloths and cleaning solvents and wipe dry with clean cloths. Do not leave a film or greasy residue on the cleaned surfaces before abrasive blasting.
- B. Remove weld spatter and weld slag from metal surfaces and grind smoothly rough welds, beads, peaked corners, and sharp edges including erection lugs in accordance with SSPC SP-2 and SSPC SP-3. Grind 0.020 inch (minimum) off the weld caps on pipe weld seams. Grind outside sharp corners, such as the outside edges of flanges, to a minimum radius of 1/4 inch.
- C. Do not abrasive blast or prepare more surface area in one day than can be coated in one day; prepare surfaces and apply coatings the same day. Remove sharp edges, burrs, and weld spatter.
- D. Do not abrasive blast PVC piping or equipment. Do not abrasive blast epoxy- or enamel-coated pipe that has already been factory coated, except to repair scratched or damaged coatings.

- E. For carbon steel, do not touch the surface between the time of abrasive blasting and the time the coating is applied. Apply coatings within two hours of blasting or before any rust bloom forms.
- F. Surface preparation shall conform with the SSPC specifications as follows:

Solvent Cleaning	SP-1
Hand Tool Cleaning	SP-2
Power Tool Cleaning	SP-3
White Metal Blast Cleaning	SP-5
Commercial Blast Cleaning	SP-6
Brush-Off Blast Cleaning	SP-7
Pickling	SP-8
Near-White Blast Cleaning	SP-10
Power Tool Cleaning to Bare Metal	SP-11
Surface Preparation and Cleaning of Steel and Other Hard Materials by High- and Ultrahigh-Pressure Water Jetting Prior to Recoating	SP-12
Surface Preparation of Concrete	SP-13

- G. Wherever the words “solvent cleaning,” “hand tool cleaning,” “wire brushing,” or “blast cleaning” or similar words are used in these specifications or in paint manufacturer’s specifications, they shall be understood to refer to the applicable SSPC (Society for Protective Coatings), surface preparation specifications listed above.
- H. Dust blasting is defined as cleaning the surface through the use of very fine abrasives, such as siliceous or mineral abrasives, 80 to 100 mesh. Apply a fine etch to the metal surface to clean the surface of any contamination or oxide and to provide a surface profile for the coating.

- I. Brush-off blasting of concrete and masonry surfaces is defined as opening subsurface holes and voids and etching the surface for a coating to bond.
- J. For carbon steel surfaces, after abrasive blast cleaning, the height of the surface profile shall be 2 to 3 mils. Verify the surface profile by measuring with an impresser tape acceptable to the Construction Manager. Perform a minimum of one test per 100 square feet of surface area. Testing shall be witnessed by the Construction Manager. The impresser tape used in the test shall be permanently marked with the date, time, and locations where the test was made. Test results shall be promptly presented to the Construction Manager.
- K. Do not apply any part of a coating system before the Construction Manager has reviewed the surface preparation. If coating has been applied without this review, if directed by the Construction Manager, remove the applied coating by abrasive blasting and reapply the coat in accordance with this specification.

3.03. ABRASIVE BLAST CLEANING

- A. Use dry abrasive blast cleaning for metal surfaces. Do not use abrasives in automatic equipment that have become contaminated. When shop or field blast cleaning with handheld nozzles, do not recycle or reuse blast particles.
- B. After abrasive blast cleaning and prior to application of coating, dry clean surfaces to be coated by dusting, sweeping, and vacuuming to remove residue from blasting. Apply the specified primer or touch-up coating within the period of an eight-hour working day. Do not apply coating over damp or moist surfaces. Reclean prior to application of primer or touch-up coating any blast cleaned surface not coated within said eight-hour period.
- C. Keep the area of the work in a clean condition and do not permit blasting particles to accumulate and constitute a nuisance or hazard.
- D. During abrasive blast cleaning, prevent damage to adjacent coatings. Schedule blast cleaning and coating such that dust, dirt, blast particles, old coatings, rust, mill scale, etc., will not damage or fall upon wet or newly coated surfaces.

3.04. COATING STAINLESS STEEL

- A. Solvent clean per SSPC SP-1. Solvents and cleaning solutions shall contain less than 200 mg/L of halogens. Then abrasive blast to give a surface profile of 2.0 to 3.0 mils.

- B. Do not apply inorganic zinc primers to stainless steel if such primers are specified in the painting system required. Apply only the intermediate and finish coats in such cases.

3.05. PROCEDURES FOR ITEMS HAVING SHOP-APPLIED PRIME COATS

- A. After application of primer to surfaces, allow coating to cure for a minimum of two hours before handling to minimize damage.
- B. When loading for shipment to the project site, use spacers and other protective devices to separate items to prevent damaging the shop-primed surfaces during transit and unloading. If wood spacers are used, remove wood splinters and particles from the shop-primed surfaces after separation. Use padded chains or ribbon binders to secure the loaded items and minimize damage to the shop-primed surfaces.
- C. Cover shop-primed items 100% with protective coverings or tarpaulins to prevent deposition of road salts, fuel residue, and other contaminants in transit.
- D. Handle shop-primed items with care during unloading, installation, and erection operations to minimize damage. Do not place or store shop-primed items on the ground or on top of other work unless ground or work is covered with a protective covering or tarpaulin. Place shop-primed items above the ground upon platforms, skids, or other supports.

3.06. FIELD TOUCH-UP OF SHOP-APPLIED PRIME COATS

- A. Remove oil and grease surface contaminants on metal surfaces in accordance with SSPC SP-1. Use clean rags wetted with a degreasing solution, rinse with clean water, and wipe dry.
- B. Remove dust, dirt, salts, moisture, chalking primers, or other surface contaminants that will affect the adhesion or durability of the coating system. Use a high-pressure water blaster or scrub surfaces with a broom or brush wetted with a solution of trisodium phosphate, detergent, and water. Before applying intermediate or finish coats to inorganic zinc primers, remove any soluble zinc salts that have formed by means of scrubbing with a stiff bristle brush. Rinse scrubbed surfaces with clean water.
- C. Remove loose or peeling primer and other surface contaminants not easily removed by the previous cleaning methods in accordance with SSPC SP-7. Take care that remaining primers are not damaged by the blast cleaning operation. Remaining primers shall be firmly bonded to the steel surfaces with blast cleaned edges feathered.

- D. Remove rust, scaling, or primer damaged by welding or during shipment, storage, and erection in accordance with SSPC SP-10. Take care that remaining primers are not damaged by the blast cleaning operation. Areas smaller than 1 square inch may be prepared per SSPC SP-11. Remaining primers shall be firmly bonded to the steel surfaces with cleaned edges feathered.
- E. Use repair procedures on damaged primer that protects adjacent primer. Blast cleaning may require the use of lower air pressure, smaller nozzles, and abrasive particle sizes, short blast nozzle distance from surface, shielding, and/or masking.
- F. After abrasive blast cleaning of damaged and defective areas, remove dust, blast particles, and other debris by dusting, sweeping, and vacuuming; then apply the specified touch-up coating.
- G. Surfaces that are shop primed with inorganic zinc primers shall receive a field touch-up of organic zinc primer per System No. 18 to cover scratches or abraded areas.
- H. Other surfaces that are shop primed shall receive a field touch-up of the same primer used in the original prime coat.

3.07. PAINTING SYSTEMS

- A. All materials of a specified painting system, including primer, intermediate, and finish coats, shall be produced by the same manufacturer. Thinners, cleaners, driers, and other additives shall be as recommended by the paint manufacturer for the particular coating system.
- B. Deliver paints to the jobsite in the original, unopened containers.

3.08. PAINT STORAGE AND MIXING

- A. Store and mix materials only in areas designated for that purpose by the Construction Manager. The area shall be well-ventilated, with precautionary measures taken to prevent fire hazards. Post "No Smoking" signs. Storage and mixing areas shall be clean and free of rags, waste, and scrapings. Tightly close containers after each use. Store paint at an ambient temperature from 50°F to 100°F.
- B. Prepare multiple-component coatings using all of the contents of the container for each component as packaged by the paint manufacturer. Do not use partial batches. Do not use multiple-component coatings that have been mixed beyond their pot life. Provide small quantity kits for touch-up painting and for painting other small areas.

Mix only the components specified and furnished by the paint manufacturer. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

3.09. PROCEDURES FOR THE APPLICATION OF COATINGS

- A. Conform to the requirements of SSPC PA-1. Follow the recommendations of the coating manufacturer including the selection of spray equipment, brushes, rollers, cleaners, thinners, mixing, drying time, temperature and humidity of application, and safety precautions.
- B. Stir, strain, and keep coating materials at a uniform consistency during application. Power mix components. For multiple component materials, premix each component before combining. Apply each coating evenly, free of brush marks, sags, runs, and other evidence of poor workmanship. Use a different shade or tint on succeeding coating applications to indicate coverage where possible. Finished surfaces shall be free from defects or blemishes.
- C. Do not use thinners unless recommended by the coating manufacturer. If thinning is allowed, do not exceed the maximum allowable amount of thinner per gallon of coating material. Stir coating materials at all times when adding thinner. Do not flood the coating material surface with thinner prior to mixing. Do not reduce coating materials more than is absolutely necessary to obtain the proper application characteristics and to obtain the specified dry-film thicknesses.
- D. Remove dust, blast particles, and other debris from blast cleaned surfaces by dusting, sweeping, and vacuuming. Allow ventilator fans to clean airborne dust to provide good visibility of working area prior to coating applications. Remove dust from coated surfaces by dusting, sweeping, and vacuuming prior to applying succeeding coats.
- E. Apply coating systems to the specified minimum dry-film thicknesses as determined per SSPC PA-2.
- F. Apply primer immediately after blast cleaning and before any surface rusting occurs, or any dust, dirt, or any foreign matter has accumulated. Reclean surfaces by blast cleaning that have surface colored or become moist prior to coating application.
- G. Apply a brush coat of primer on welds, sharp edges, nuts, bolts, and irregular surfaces prior to the application of the primer and finish coat. Apply the brush coat prior to and

in conjunction with the spray coat application. Apply the spray coat over the brush coat.

- H. Before applying subsequent coats, allow the primer and intermediate coats to dry for the minimum curing time recommended by the manufacturer. In no case shall the time between coats exceed the manufacturer's recommendation.
- I. Each coat shall cover the surface of the preceding coat completely, and there shall be a visually perceptible difference in applied shade or tint of colors.
- J. Applied coating systems shall be cured at 75°F or higher for 48 hours. If temperature is lower than 75°F, curing time shall be in accordance with printed recommendations of the manufacturer, unless otherwise allowed by the Construction Manager.
- K. Assembled parts shall be disassembled sufficiently before painting or coating to ensure complete coverage by the required coating.

3.10. SURFACES NOT TO BE COATED

- A. Do not paint the following surfaces unless otherwise noted in the drawings or in other specification sections. Protect during the painting of adjacent areas:
 - 1. Concrete walkways.
 - 2. Mortar-coated pipe and fittings.
 - 3. Stainless steel.
 - 4. Metal letters.
 - 5. Glass.
 - 6. Fencing.
 - 7. Copper tubing, red brass piping, and PVC piping except where such piping occurs in rooms where the walls are painted, or required for color coding.
 - 8. Electrical fixtures except for factory coatings.
 - 9. Nameplates.
 - 10. Grease fittings.

11. Brass and copper, submerged.
12. Buried pipe, unless specifically required in the piping specifications.
13. Aluminum handrail, stairs, and grating.
14. Insulated pipe.

3.11. PROTECTION OF SURFACES NOT TO BE PAINTED

- A. Remove, mask, or otherwise protect hardware, lighting fixtures, switchplates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not intended to be painted. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process. Mask openings in motors to prevent paint and other materials from entering the motors.

3.12. SURFACES TO BE COATED

- A. The exact coating to be applied in any location is not designated by the descriptive phrases in the coating system titles such as “corrosive environment,” “buried metal,” or “submerged metal.” Coat surfaces with the specific coating systems as shown in the finish schedule and as described below:

1. Coat mechanical equipment such as pumps as described in the various mechanical equipment specifications. Color of finish coat shall be as shown.
2. Coat aboveground and exposed piping or piping in vaults and structures as described below. Color of finish coat shall be as shown below:

Piping Designation	Color of Finish Coat
PW (Potable Water)	BLUE
RW (Raw Water)	OLIVE GREEN
SS (Sanitary Sewer)	GREEN
DR (Storm Drain)	GRAY

3. Coat submerged steel and ductile iron piping and piping in wet wells System No. 7.

4. Coat valves as described the same as the adjacent piping. Aboveground valves, or valves in vaults and structures, shall match the color of the connecting piping.
5. Coat buried flanges, nuts and bolts, valves, flexible pipe couplings, exposed rebar in thrust blocks, and valve boxes per System No. 21. Coat buried bolt threads, tie bolt threads, and nuts per System No. 24.

3.13. DRY-FILM THICKNESS TESTING

- A. Measure coating thickness specified for carbon steel surfaces with a magnetic-type dry-film thickness gauge in accordance with SSPC PA-2. Measure coating thickness specified for stainless steel, aluminum, and copper surfaces with an eddy-current type thickness gauge per ASTM D1400. Provide certification that the gauge has been calibrated by a certified laboratory within the past six months. Provide dry-film thickness gauge as manufactured by Mikrotest or Elcometer.
- B. Test the finish coat of metal surfaces (except zinc primer and galvanizing) for holidays and discontinuities with an electrical holiday detector, low-voltage, wet-sponge type. Provide measuring equipment. Provide certification that the gauge has been calibrated by a certified laboratory within the past six months. Provide detector as manufactured by Tinker and Razor or K-D Bird Dog.
- C. Measure coating thickness specified for concrete or masonry surfaces in accordance with ASTM D4138. Test the finish coat of concrete and masonry surfaces in accordance with NACE RP-0188-90 or ASTM D4787. Patch coatings at the points of thickness measurement or holiday detection.
- D. Check each coat for the correct dry-film thickness. Do not measure within eight hours after application of the coating.
- E. For metal surfaces, make five separate spot measurements (average of three readings) spaced evenly over each 100 square feet of area (or fraction thereof) to be measured. Make three readings for each spot measurement of either the substrate or the paint. Move the probe or detector a distance of 1 to 3 inches for each new gauge reading. Discard any unusually high or low reading that cannot be repeated consistently. Take the average (mean) of the three readings as the spot measurement. The average of five spot measurements for each such 100-square-foot area shall not be less than the specified thickness. No single spot measurement in any 100-square-foot area shall be less than 80% nor more than 120%, of the specified thickness. One of three readings

which are averaged to produce each spot measurement may underrun by a greater amount as defined by SSPC PA-2.

- F. For concrete surfaces, make five separate spot measurements spaced evenly over each 100 square feet of area (or fraction thereof) to be measured. The average of five spot measurements for each such 100-square-foot area shall not be less than the specified thickness. No single spot measurement in any 100-square-foot area shall be less than 80%, nor more than 120%, of the specified thickness.
- G. Perform tests in the presence of the Construction Manager.

3.14. REPAIR OF IMPROPERLY COATED SURFACES

- A. If the item has an improper finish color or insufficient film thickness, clean and topcoat the surface with the specified paint material to obtain the specified color and coverage. Sandblast or power-sand visible areas of chipped, peeled, or abraded paint, feathering the edges. Then prime and finish coat in accordance with the specifications. Work shall be free of runs, bridges, shiners, laps, or other imperfections.

3.15. CLEANING

- A. During the progress of the work, remove discarded materials, rubbish, cans, and rags at the end of each day's work.
- B. Thoroughly clean brushes and other application equipment at the end of each period of use and when changing to another paint or color.
- C. Upon completion of painting work, remove masking tape, tarps, and other protective materials, using care not to damage finished surfaces.

END OF SECTION

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SECTION 09 97 06

POLYETHYLENE ENCASEMENT (AWWA C105)

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials and installation of a polyethylene sheet encasement for buried steel and iron pipe, fittings, and valves.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's catalog literature and product data sheets describing the physical, chemical, and electrical properties of the encasement material.

PART 2 - MATERIALS

2.01. POLYETHYLENE WRAP

- A. The encasement shall consist of low-density polyethylene wrap of at least 8-mil thickness conforming to AWWA C105.
- B. Polyethylene encasement for ductile-iron pipe shall be supplied as a flat tube meeting the dimensions of Table 1 in AWWA C105 and shall be supplied by the ductile-iron pipe manufacturer.

2.02. PLASTIC ADHESIVE TAPE

- A. Tape shall consist of polyolefin backing and adhesive which bonds to common pipeline coatings including polyethylene.
- B. Minimum Width: Two inches.
- C. Products: Canusa Wrapid Tape; Tapecoat 35; Polyken 934; AA Thread Seal Tape, Inc.; or approved equal.

PART 3 - EXECUTION

3.01. BURIED PIPING AND FITTINGS APPLICATION

- A. Apply wrapping per AWWA C105 as modified herein.
- B. Apply double wrapping.
- C. Install the polyethylene to completely encase the pipe and fittings to provide a watertight corrosion barrier. Continuously secure overlaps and ends of sheet and tube with polyethylene tape. Make circumferential seams with two complete wraps, with no exposed edges. Tape longitudinal seams and longitudinal overlaps, extending tape beyond and beneath circumferential seams.
- D. Wrap bell-spigot interfaces, restrained joint components, and other irregular surfaces with wax tape or moldable sealant prior to placing polyethylene encasement.
- E. Minimize voids beneath polyethylene. Place circumferential or spiral wraps of polyethylene tape at 2-foot intervals along the barrel of the pipe to minimize the space between the pipe and the polyethylene.
- F. Overlap adjoining polyethylene tube coatings a minimum of 1-foot and wrap prior to placing concrete anchors, collars, supports, or thrust blocks. Hand-wrap the polyethylene sheet, apply two complete wraps with no exposed edges to provide a watertight corrosion barrier, and secure in place with 2-inch-wide plastic adhesive tape.

3.02. BURIED VALVES APPLICATION

- A. Wrap flanges and other irregular surfaces with wax tape or moldable sealant. Press tightly into place leaving no voids underneath and a smooth surface under coating for polyethylene sheet.
- B. Wrap with a flat sheet of polyethylene. Place the sheet under the valve and the flanges or joints with the connecting pipe and fold in half. Extend the sheet to the valve stem and secure the sheet in place with 2-inch-wide plastic adhesive tape. Apply a second layer and secure with tape. Make two complete wraps, with no exposed edges, to provide a watertight corrosion barrier. Secure the sheets with tape around the valve stem below the operating nut and around the barrel of the connecting pipe to prevent the entrance of water and soil. Place concrete anchor and support blocks after the wrap has been installed.

3.03. TO BURIED FLEXIBLE PIPE COUPLINGS APPLICATION

- A. Wrap irregular surfaces with wax tape or moldable sealant. Press tightly into place leaving no voids underneath and a smooth surface under coating for polyethylene sheet.
- B. Apply two layers or wraps around the coupling. Overlap the adjoining pipe or fitting a minimum of 1-foot and secure in place with tape. Provide sufficient slack in polyethylene to allow backfill to be placed around fitting without tearing polyethylene. Apply tape around the entire circumference of the overlapped section on the adjoining pipe or fitting in two complete wraps, with no exposed edges, to provide a watertight corrosion barrier.

3.04. POLYETHYLENE MATERIAL REPAIR

- A. Repair polyethylene material that is damaged during installation. Use polyethylene sheet, place over damaged or torn area, and secure in place with 2-inch-wide plastic adhesive tape.

3.05. EXISTING BURIED PIPING APPLICATION

- A. When connecting polyethylene-encased pipe or fittings to existing pipe, expose existing pipe, thoroughly clean the surface, and securely tape the end of the polyethylene to the existing as specified above. When the existing pipe is polyethylene encased, wrap new polyethylene encasement over the existing, with overlap of at least 2 feet. Tape securely as specified above.

3.06. BACKFILLING POLYETHYLENE-WRAPPED FACILITIES

- A. Place sand backfill within 1-foot of the pipe, valves, and fittings wrapped with polyethylene encasement.

END OF SECTION

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SECTION 09 97 12

FUSION-BONDED EPOXY (FBE) COATINGS AND LININGS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials, application procedures, and testing for fusion-bonded epoxy coatings and linings for the interior and exterior surfaces of ductile-iron piping, pipe specials, connections, fittings, field-welded pipe joints, and pipe equipment, such as valves and couplings, in accordance with AWWA C116, AWWA C213, and AWWA C550.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's catalog literature and product data sheets describing the physical, chemical, and electrical properties of the coating.
- C. Submit test certificates of physical and performance characteristics of the coating.
- D. Submit coating application test records for measured coating thickness and holiday detection for each item, pipe, or piece of equipment.
- E. Submit the coating application, curing requirements, and repair procedure approved by the manufacturer.
- F. Submit National Sanitation Foundation (NSF) Standard 61 listing information for the coating including approved colors, coating thicknesses, number of coats, and curing requirements.
- G. Submit affidavit of compliance with the referenced standards.
- H. Submit the names and qualifications of the workers and supervisors to be employed on the coating operation a minimum of 14 days prior to the start of coating operations.

1.03. QUALITY CONTROL

- A. Supervisors of the coating operation shall have at least two years' continuous experience in the application of fusion-bonded epoxy coating.

1.04. INSPECTION

- A. The Owner may elect to assign a representative to inspect the entire coating procedure from surface preparation to completion of the coating. Inspection may be on a full-time or on a periodic basis. Such inspection shall not relieve the Contractor of responsibility to furnish materials and perform work in accordance with this specification.

PART 2 - MATERIALS

2.01. SHOP-APPLIED FBE LINING AND COATING

- A. Lining and coating shall be a 100% solids, thermosetting, fusion-bonded, dry powder epoxy resin compounded with curing agents, fillers, colorants, flow control agents, and ultraviolet (UV) light resistant agents.
- B. For surfaces in contact with potable water, the fusion-bonded epoxy coating shall be NSF Standard 61 certified.
- C. Total dry film thickness shall be eight (8) mils minimum, unless specified otherwise by NSF Standard 61 requirements.
- D. Fusion-bonded epoxy coating shall have the following properties:

Property	Value	Test Method
Impact	100 lbf in., minimum	Gardner Impact Tester
Shear Adhesion	3,000 psi, minimum	ASTM D1002
Abrasion Resistance (5,000 Cycles)	0.3 gm loss, maximum	ASTM D1044
Volume Resistivity	1.1×10^{15} , maximum	ASTM D257
Dielectric Strength	1.000 V/mil, minimum	ASTM D149
Tensile Strength	7,000 psi, minimum	ASTM D2370
Penetration	0	ASTM G17
Hardness	Rockwell "M" 50	ASTM D785

- E. For ductile iron pipe, it may be necessary to limit the coating and lining thickness in joint areas, to not less than four-mils, to provide a leakproof joint.

- F. NSF Standard 61 certified, fusion-bonded epoxy coating shall be Azko Nobel Resicoat R4-ES, 3M™ Scotchkote™ 134, 3M™ Scotchkote™ 206N, Axalta® NAP-GARD® 7-2500, or approved equal.

2.02. LIQUID-EPOXY PATCHING COMPOUND

- A. For lining and coating repair, use a two-part, 100% solids, liquid-epoxy patching compound compatible with the fusion-bonded epoxy lining or coating. Total dry film thickness shall be between 12 and 16-mils, unless otherwise specified by NSF Standard 61 requirements.

PART 3 - EXECUTION

3.01. SURFACE PREPARATION – DUCTILE IRON SURFACES

- A. Clean and prepare metal surfaces in accordance with the fusion-bonded epoxy manufacturer's recommendations.

3.02. SHOP APPLIED FBE LINING AND COATING

- A. Piping, pipe specials, mechanical couplings, fittings, pipe equipment, and other appurtenances shall be preheated in accordance with the epoxy manufacturer's recommendation but shall not exceed 500°F. Temperature shall be monitored at all times. The heat source shall not leave any residue or contaminants on the metal surfaces.
- B. The fusion-bonded epoxy powder shall be applied uniformly to the preheated pipe to the specified cure-film thickness. The method of epoxy application (i.e., electrostatic spray, fluidized bed process) depends on the size, shape, and configuration of the item to be coated.
- C. Threaded surfaces shall not be fusion-bonded epoxy coated but coated with rust-preventing oil.

3.03. TESTING

- A. After completion of the coating operation, the coating shall be cooled with water or air and inspected for holidays and coating thickness.
- B. For holiday testing, if the number of holidays is fewer than one per 20 square feet of coating surface, repair the holidays by applying the coating manufacturer's

recommended patching compound to each holiday and retest. If the number of holidays exceeds one per 20 square feet of coating surface, remove the entire lining or coating and recoat.

- C. For coating thickness testing, measure the coating thickness at three locations on each item, pipe, or piece of equipment, using a coating thickness gauge calibrated at least once every eight hours. Record each measured thickness value. Where individual measured thickness values are less than the specified minimum thickness, measure the coating thickness at three additional points around the defective area. The average of these measurements shall exceed the specified minimum thickness value. No individual thickness value shall be more than two-mils below or three-mils above the specified minimum value. If an item, pipe, or piece of equipment does not meet these criteria, remove the entire lining or coating and recoat.

3.04. LINING AND COATING REPAIR

- A. Minor defects shall be repaired with liquid epoxy patching compound.
- B. Roughen the edge of the existing coating or lining around the damaged area such that the patch overlaps the existing coating or lining by a minimum of one-inch.
- C. The liquid epoxy patching compound shall be applied uniformly to the defective area to the specified cure-film thickness. Liquid epoxy patching compound shall not be applied if the pipe temperature is 55°F, or less. After patching, repair areas shall be re-inspected for holidays.
- D. Pipe sections with major defects, such as partial coating or disbondment, shall be reprocessed starting with blast cleaning surface preparation. For field patching, if a defective area exceeds 20 square inches, remove the entire lining or coating and recoat.

3.05. STORAGE

- A. Pipe and appurtenances requiring storage prior to installation shall be protected as recommended by the coating manufacturer.

END OF SECTION

SECTION 09 97 18

HEAT-SHRINKABLE CROSS-LINKED POLYOLEFIN COATINGS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials, application, and inspection of a heat-shrinkable polyolefin sleeve coating complying with AWWA C216 (Type I or II), except as modified herein, for buried steel pipe.
- B. Refer to Section 33 11 11 for specific instructions regarding the use of sleeves specified in this Section during Weld-after-Backfill (WAB) operations.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's catalog literature and product data sheets describing the physical, chemical, and electrical properties of the heat-shrinkable coating.
- C. Submit results of material and coating system tests per AWWA C216, Section 5.1. The cost of testing coating samples shall be borne by the supplier and applicator.
- D. Submit method approved by manufacturer to minimize voids at weld seams.
- E. Submit application and curing procedure approved by the coating manufacturer.
- F. Submit affidavit of compliance with the referenced standards (e.g., AWWA C216).
- G. Submit the names and qualifications of the workers and supervisors to be employed on the coating operation a minimum of 14 days prior to the start of coating operations.
- H. Submit the type and model of portable holiday detector intended for use on the project plus a plan indicating the intended holiday detection process.

1.03. QUALITY CONTROL

- A. Supervisors of coating operations shall have at least two years' continuous recent experience in the application of heat-shrinkable coatings for steel pipe and appurtenances.
- B. The manufacturer of the coating shall demonstrate a minimum of five years of successful application of this product on large diameter steel water pipelines.

1.04. INSPECTION

- A. The entire procedure of applying the protective heat shrink coating material will be inspected by the Construction Manager from surface preparation to completion of coating. Such inspection shall not relieve the Contractor of responsibility to furnish material and perform work in accordance with this specification. Coating work shall be done in the presence of the Construction Manager. Coating work done in the Construction Manager's absence will be subject to rejection.

PART 2 - MATERIALS

2.01. HEAT-SHRINKABLE POLYOLEFIN SLEEVE COATING SYSTEM

- A. The coating shall be field-applied and shall consist of three components:
 - 1. Filler mastic
 - 2. Protective underlayment sleeve
 - 3. Polyolefin outer shrink sleeve.

2.02. MOLDABLE MASTIC FILLER

- A. A butyl rubber transition filler shall be applied to provide a smooth transition between the bell and spigot edges prior to placement of the protective underlayment and the heat-shrinkable polyolefin sleeves in order to prevent tenting and entrapped air. Filler shall be Canusa-CPS AquaSeal SG79 or Polyken #939.

2.03. POLYOLEFIN SHRINK SLEEVE

- A. Normal Installation
 - 1. The polyolefin heat-shrink sleeve and shall comply with AWWA C216, Type II. Sleeve shall be Canusa-CPS AQW-HS, Covalence WaterWrap, or approved equal.
- B. Weld After Backfill
 - 1. The polyolefin heat-shrink sleeve shall comply with AWWA C216, Type II. Sleeve shall be Canusa-CPS AQW-WAB, Covalence WaterWrap WAB, or approved equal.
 - 2. A protective underlayment sleeve shall be applied prior to installing the heat shrink sleeve for weld after backfill applications to provide additional temperature resistance during internal welding. Underlayment sleeve shall be compatible with and from the same manufacturer as the heat-shrink sleeve.

PART 3 - EXECUTION

3.01. SURFACE PREPARATION

- A. Prepare pipe surfaces for coating in accordance with AWWA C216, Section 4.4; and SSPC SP-6. Wire brush cleaned surfaces shall leave a coarse profile such that the surface is not polished. Blast cleaned surface profile shall be angular and a minimum of two-mils from peak-to-valley. Remove welding slag, scale, and splash globules by wire brushing. Remove oil or chemicals remaining on metal surfaces after preliminary cleaning by abrasive blasting. Do not reuse grit used in such removals in any subsequent preparation operations. Wipe pipe to be free of dust or grit immediately prior to application of the adhesive.
- B. Bevel the edge of the adjacent pipe coating to 30°, or less, prior to the installation of the heat-shrinkable coating system.
- C. Preheat the pipe to at least 5°F above the dew point prior to surface cleaning.

3.02. APPLICATION OF MOLDABLE MASTIC FILLER

- A. Apply compatible, moldable mastic filler at the step down area prior to the application of the underlayment and heat-shrinkable sleeve.

3.03. UNDERLAYMENT AND HEAT-SHRINK SLEEVE APPLICATION

- A. Install the heat-shrinkable sleeve coating system before any corrosion products form and within four hours of surface preparation. If the heat-shrinkable sleeve coating system is not installed within four hours of the surface preparation, repeat the surface preparation procedures.
- B. Preheat the steel joint area using two propane torches such that no moisture is visible and the surface temperature is between 104°F - 140°F. Apply the underlayment sleeve as part of a process that minimizes loss of pre-heat. The underlayment sleeve shall be placed directly centered over the location of the internal lap weld. Once the underlayment sleeve is applied, gently heat to remove any wrinkling in preparation for the application of the outer heat shrink sleeve.
- C. Apply the outer heat-shrink sleeve with a three-inch (minimum) overlap of the adjacent pipe tape coatings. Sweep, blast, or manually-abrade the adjacent pipe coating over which the heat-shrinkable coating will be applied. Protect existing pipe coatings that are not being coated from damage by impact, gouging, mechanical cleaning, or any other contact.
- D. Wrap the sleeve firmly but not tightly around the joint. Apply heat to the sleeve on the spigot end of the pipe first and then to the sleeve around the bell end of the pipe. Apply heat such that the sleeve shrinks firmly and uniformly around the joint.

3.04. HOLIDAY TESTING AND COATING THICKNESS MEASUREMENT

- A. Test the entire surface for electrical continuity using a portable electric holiday detector operating at minimum of 1,500-volts. The coating system shall show no defects when subjected to the electrical holiday detector test as specified in AWWA C216, Section 5.5. Repair defects per AWWA C216, paragraph 4.6.

3.05. COATING REPAIR

- A. Damaged or defective areas shall be repaired in accordance with the heat-shrinkable coating manufacturer's recommendations and AWWA C216.
- B. All repair areas shall be re-tested for holidays.

3.06. TRENCH BACKFILLING

- A. Backfill over the heat-shrinkable coating only after the coating system has cooled to ambient temperature. The backfill material shall not contain any material that will damage the coating system.

END OF SECTION

SECTION 09 97 20

POLYURETHANE PROTECTIVE COATINGS AND LININGS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials, application, and testing of two-component solvent-free polyurethane systems formulated for use as an external coating for steel pipe and fittings. Coating shall comply with AWWA Standard C222 and the following options and restrictions.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit results of laboratory tests to confirm that the polyurethane coating meets the requirements specified herein.
- C. Submit affidavit that all material and work provided comply with the requirements of AWWA Standard C222 and this specification.
- D. Submit an affidavit that all of the coating materials furnished are of the same formulation that was laboratory tested by the manufacturer and found to meet or exceed the performance requirements of AWWA Standard C222 and this specification.
- E. Submit samples of coated materials for testing by the owner or a test laboratory selected by the owner.
- F. Submit manufacturer's data sheets showing the following information:
 - 1. Percent solids by volume.
 - 2. Recommended surface preparation.
 - 3. Recommended thinners, if any.
 - 4. Application instructions including recommended equipment by make and model number, and application temperature and humidity limitations.
 - 5. Manufacturer's maximum recommended recoat time.

6. Curing requirements and instructions.

7. Color samples.

G. Provide submittal identifying the type and gradation of abrasives used for surface preparation.

H. If applicable, submit certificate stating that the lining complies with the requirements of ANSI/NSF 61 for submerged coatings for potable water service.

I. Submit Coating inspection and QC Procedures prior to start of coating. Submit complete records of all coatings inspections including test coupons.

J. Submit proof that coating and lining material has a minimum of 5 years of case histories in similar pipeline applications.

1.03. INSPECTION

A. The Owner may elect to assign a representative to inspect the entire coating procedure from surface preparation to completion of the coating. Inspection may be on a full-time or on a periodic basis. Such inspection shall not relieve the Contractor of responsibility to furnish material and perform work in accordance with this specification.

PART 2 - MATERIALS

2.01. POLYURETHANE MATERIAL

A. The polyurethane material shall be a solvent-free, ASTM D16 Type V thermoset, aromatic polyurethane plastic polymer system complying with AWWA C222 and as specified herein.

B. Properties:

1. Conversion to Solids by Volume: After mixing the resins, the liquid polyurethane shall convert to a cured solid on a minimum 98.0% ($\pm 0.5\%$) basis (ASTM D1259, Method A).
2. Temperature Resistance: The cured material shall be suitable for service between -40°F and $+140^{\circ}\text{F}$.

3. Adhesion: The cured polyurethane, when applied to pipe that has been blasted to an SSPC SP-10 finish, shall have an adhesion value in excess of 2,000 psi per ASTM D4541.
4. Tack-Free Time: The tack-free time for the polyurethane material shall not exceed 10 minutes at 120°F or 30 minutes at 0°F.
5. Cure Time: The polyurethane shall achieve sufficient cure for handling in less than 15 minutes at 120°F and full cure within seven days at 70°F.
6. Impact Resistance: Not less than 75 inch-pounds using a one-inch-diameter steel ball per ASTM G14 where the polyurethane is applied at 25 mils to a pipe surface which has been blasted to an SSPC SP-10 finish.
7. Tensile Strength: The polyurethane shall have a tensile strength of not less than 3,000 psi.
8. Hardness: The polyurethane shall have a hardness of 70 to 80 Shore D at 70°F (ASTM D2240).
9. Flexibility: The polyurethane shall be capable of passing the test prescribed by ASTM D522 using a one-inch mandrel at a temperature of 70°F. The polyurethane must be allowed to cure for seven days. Perform testing on coupons held for 15 minutes at a temperature of 70°F.
10. Abrasion Resistance: Less than 85 mg loss per thousand revolutions with Taber CS17 wheel at 1 kg (ASTM D4060).
11. Dielectric Strength: Greater than 250 volts per mil.

C. Products

1. Carboline, Polyclad 777.
2. LifeLast, Durashield 110.
3. Sherwin-Williams, Corropipe 3000.
4. Chemline 2265
5. Or approved equal.

2.02. EXTERIOR COATING THICKNESS

- A. Apply coating to pipe exterior to a total thickness of 30 mils minimum unless otherwise noted on the Drawings.

2.03. REPAIR MATERIALS FOR FIELD-DAMAGED AREAS

- A. Materials utilized for field-applied coatings and linings shall be manufactured by the same manufacturer that made the shop-applied coating and lining. The field-applied coatings and linings shall be chemically compatible with the shop-applied coating and lining.

2.04. ABRASIVES FOR SURFACE PREPARATION

- A. Abrasives used for preparation of iron and steel surfaces shall be one of the following:
 - 1. 16 to 30 or 16 to 40 mesh silica sand or mineral grit.
 - 2. 20 to 40 mesh garnet.
 - 3. Crushed iron slag, 100% retained on No. 80 mesh.
 - 4. SAE Grade G-40 or G-50 iron or steel grit.
- B. In the above gradations, 100% of the material shall pass through the first stated sieve size and 100% shall be retained on the second stated sieve size.

PART 3 - EXECUTION

3.01. SURFACE PREPARATION

- A. Do not abrasive blast or prepare more surface area in one day than can be coated in one day. Apply coatings within eight hours after surface has been prepared.
- B. Grind surface irregularities smooth before applying the coating. The allowable grind area shall not exceed 0.5 square foot per location, and the maximum total grind area shall not exceed two square feet for pipe section or fitting. Do not use any pipe in which these requirements cannot be met.
- C. Remove surface imperfections including slivers, scales, burrs, and gouges. Grind outside sharp corners, such as the outside edges of flanges, to a smooth radius.

- D. Before blast cleaning, remove visible deposits of oil, grease, or other organic contaminants by using a solvent wash as specified in SSPC SP-1. Surfaces to be coated shall be completely dry and free of moisture, dust, grit, oil, grease, or any other deleterious substance at the time the polyurethane is applied. Use clean cloths and cleaning solvents and wipe dry with clean cloths. Do not leave a film or greasy residue on the cleaned surfaces before abrasive blasting.
- E. Prepare surface areas to be lined to the requirements of SSPC SP-10, with a minimum of 95% of the visible oxide film removed. The anchor pattern shall be 3 to 4 mils deep.
- F. If the surface temperature of the pipe is less than 5°F above the dew point uniformly preheat pipe and fittings to a temperature adequate to provide uniform fusing of the polyurethane and proper bonding to the pipe and fittings. The preheat shall be sufficient to ensure that the surface temperature is at least 5°F above the dew point temperature during blast cleaning and inspection.
- G. Grind smooth the weld reinforcement before beginning the surface preparation and heating of the pipe.
- H. Remove weld spatter and weld slag and grind smoothly rough welds, beads, peaked corners, and sharp edges in accordance with SSPC SP-2 and SSPC SP-3.
- I. Neutralize welds with a chemical solvent that is compatible with the specified coating materials. Use clean cloths and chemical solvent. Wipe dry with clean cloths. Do not leave a residue on the cleaned surfaces.

3.02. ABRASIVE BLAST CLEANING

- A. Use dry abrasive blast cleaning for metal surfaces. Do not use abrasives that have become contaminated. Recycling of abrasives in the factory is acceptable provided the abrasives are not contaminated and provided they meet the requirements of the specifications for abrasives.
- B. After blast cleaning and prior to application of coating, clean surfaces to be coated by dusting, sweeping, and vacuuming to remove residue from blasting. Apply the specified primer or touch-up coating within the period of an eight-hour working day. Do not apply coating over damp or moist surfaces. Reclean prior to application of primer or touch-up coating any blast-cleaned surface not coated within said eight-hour period.

- C. Keep the area of the work in a clean condition and do not permit blasting particles to accumulate and constitute a nuisance or hazard.
- D. During abrasive blast cleaning, prevent damage to adjacent coatings. Schedule and locate blast cleaning and coating such that dust, dirt, blast particles, old coatings, rust, mill scale, etc., will not damage or fall upon wet or newly coated surfaces.

3.03. POLYURETHANE COATING APPLICATION

- A. Equipment: Apply the polyurethane by a two-component, heated airless spray unit in accordance with the manufacturer's written application specifications.
- B. Temperature: The temperature of the substrate shall be at least 5°F above the dew point temperature.
- C. Humidity: High humidity may cause conditions that affect performance of the polyurethane. Therefore, exercise caution if the relative humidity exceeds 85%. Heating of pipe surfaces may be required to meet these requirements.
- D. Preparation of Materials: Thinning or mixing of the resins shall not be undertaken; use as received. Store resins above 50°F at all times.
- E. Application:
 - 1. Comply with Manufacturer's recommendations.
 - 2. Apply the polyurethane directly to substrate to achieve the specified film thickness. A multiple-pass, one coat application process may be permitted provided the maximum allowable recoat time is not exceeded.
 - 3. Flange faces shall be uncoated unless specified otherwise.
- F. Stamp or stencil on the external coating the date the lining and coating were applied and by whom.
- G. Recoating: Recoating may be permitted provided the material has cured less than the maximum time specified by the manufacturer. Where the material has cured for more than the recoat time, the surface shall be brush-blasted or thoroughly abraded to create a minimum 2.5-mil profile, followed by blow-off cleaning using clean, dry, high-pressure compressed air. Maximum recoat times shall be per the manufacturer's stated recoat window or the tabulated values below whichever is less.

- H. Curing: The specified polyurethane shall cure at any ambient temperature above 0°F. Coated surfaces shall be permitted to cure as long a time as practical. The minimum cure time requirements listed below shall be met before the pipes are put into service.

Ambient Temperature	Maximum Recoat Time	Minimum Full Cure Time
Over 70°F	30 minutes	1 Day
50°F to 70°F	45 minutes	3 Days
0°F to 50°F	1 hour	6 Days

- I. Appearance: The finished polyurethane coating shall be smooth, uniform, and free of sharp protuberances, pinholes, runs, sags, drips, blisters, scratches, or other surface imperfections.

3.04. MANUFACTURER THICKNESS MEASUREMENTS

- A. Test linings and coatings per NACE SP0188-24 with a high-voltage holiday detector set at a voltage as listed in NACE SP0188-24, Table A. If the number of holidays or pinholes is less than one per 25 square feet of coating surface for internal coatings and one per 10 square feet for external coatings, repair the holidays and pinholes by applying the coating manufacturer's recommended polyurethane patching compound to each holiday or pinhole and retest. If the number of pinholes and holidays exceeds the above criteria, remove the entire lining or coating and recoat the item or pipe at the place of manufacture. Recoating may be permitted if the material has cured less than the manufacturer's recommended cure time. If the coating is outside of the lower of the manufacturer's stated recoat window or the tabulated cure times in Section 3.03H, refer to Section 3.03.G.
- B. Measure the lining and coating thickness on each pipe section using a coating thickness gauge calibrated at least once per eight-hour shift. Make five separate spot measurements (average of three readings) spaced evenly over each 100 square feet of area (or fraction thereof) to be measured. Make three gauge readings for each spot measurement of either the substrate or the paint. Move the probe a distance of 1 to 3 inches for each new gauge reading. Discard any unusually high or low gauge reading that cannot be repeated consistently. Take the average (mean) of the three gauge readings as the spot measurement. The average of five spot measurements for each such 100-square-foot area shall not be less than the specified thickness. No single spot measurement in any 100-square-foot area shall be less than 80% of the specified

thickness. One of three readings that are averaged to produce each spot measurement may underrun by a greater amount. If a section of the pipe, item, or piece of equipment does not meet these criteria, remove the entire lining or coating and recoat the entire item or piece of equipment.

C. Thickness determinations shall meet the following requirements:

1. No individual reading shall be below 75% of specified minimum.
2. Individual spot readings (consisting of three point measurements within three inches of each other) shall have an average not less than 80% of minimum.
3. The average of all spot readings shall be equal to or greater than the minimum thickness specified.

D. Thickness determinations shall be conducted using a Type 1 or 2 thickness gauge as described in SSPC PA2 specification.

3.05. MANUFACTURER REPAIR OF IMPROPER COATING

- A. If the item has an insufficient film thickness and the coating material curing time has not been exceeded, clean and topcoat the surface with the specified polyurethane repair coating to obtain the specified coverage. Abrasive blast areas of chipped, peeled, or abraded coating, feathering the edges. When blast cleaning with handheld nozzles, do not recycle or reuse blast particles. Then coat in accordance with the specifications. Work shall be free of sharp protuberances, pinholes, sags, drips, blisters, scratches, runs, bridges, shiners, laps, or other imperfections.

3.06. OWNER IN-PLANT INSPECTION AND TESTING

- A. An Owner's Representative may inspect pipe, fittings, lining, coating, and other material during fabrication at the mill, production plant, or shop. The Owner's Representative shall be allowed complete and unlimited access to all parts of the work and shall be furnished with such information and assistance by the Contractor and/or manufacturer as is required to make a complete and detailed inspection. The contractor shall notify the Owner as least seven days prior to beginning of material production and coating application.
- B. The Owner may conduct tests to determine the integrity of the lining and coating. Pipe and fittings shall be available onsite and accessible at least three days before installation to allow time for the Owner's tests. If the test results indicate any

manufacturing defect, the material shall be repaired or replaced at no extra cost to the Owner. The Owner's Representative will make a determination on whether to repair or reject defective or damages pipe or fitting.

3.07. MANUFACTURER TESTING AND CERTIFICATION

- A. Conduct laboratory tests to confirm that the polyurethane coating meets the requirements specified herein.
- B. Prior to abrasive blast cleaning, prepare visual comparative standards in accordance with AWWA C222 part 4.4.2.3. The visual standards panels shall be wrapped in 4-mil plastic and shall be sealed to prevent contamination and corrosion, and shall be maintained as a visual reference standard throughout the coating operation.
- C. Polyurethane lining of every section of pipe and fitting shall be subjected to and pass the holiday test specified above. The lining shall be free of all holidays. Cut at least one sample from each of two pipes per day and perform adhesion testing per ASTM D4541.
- D. Every section of pipe and fitting shall be delivered with certified test results of that individual pipe section or fitting. If a pipe or fitting is not accompanied by such certifications or does not meet the Owner-conducted tests as described above, the pipe or fitting will be rejected.
- E. Check for coating defects on the weld seam centerlines. There shall be no porous blisters, craters, or pimples lying along the peak of the weld crown.

3.08. FIELD REPAIR AND TOUCH-UP

- A. Up to three holidays or damaged areas on the external coating per pipe length may be repaired in the field using the coating manufacturer's polyurethane field repair material and application specifications. If more than three holidays or damaged areas per pipe exist, remove and replace the pipe.
- B. Repair Procedure – Holidays: The following repair procedure shall be used for the touch-up of minor holidays or scratches in the polyurethane.
 - 1. Remove all traces of oil, grease, dust, dirt, etc.
 - 2. Roughen the area to be patched by abrading with a rough grade sandpaper (40 grit or coarser). Avoid honing, buffing, or wire brushing because these tend to

make the surface to be repaired too smooth. The areas to be repaired shall be rough in order to offer an anchor pattern for the repair material.

3. With the area to be patched absolutely clean and suitably roughened, apply a coat of the repair materials as approved for use. Work the repair material into the scratched surface by brushing.

C. Repair Procedure – Field Cuts or Large Damage: The following repair procedures shall be used for repair of field cuts or large areas (greater than 10 square inches) of damage to the coating. It is important that the entire freshly cut exposed metal surface of the cut pipe be coated.

1. Remove burrs from field cutting of ends or handling damage and smooth cut edge of polyurethane if rough.
2. Remove all traces of oil, grease, dust, dirt, etc.
3. Remove any disbanded polyurethane caused by damage from field cutting operations or handling damage, and clean any exposed metal by sanding or scraping. Abrasive blasting or power tool cleaning/roughening is also acceptable. It is recommended that the polyurethane coating be stripped back by chiseling, cutting, or scraping into well-adhered coated area before patching. Be sure to roughen an overlap of one- to two inches of polyurethane in the area to be repaired. This roughening shall be done with a rough grade emery paper (40 grit), rasp, or small chisel. Avoid honing, buffing, or wire brushing because these tend to make the surface to be repaired too smooth for good adhesion.
4. For areas to be sealed or repaired thoroughly clean and roughened, then apply a thick coat of approved repair material. The heavy coating shall be worked into the roughened surface by brushing. Mixing and application of the repair material shall be in accordance with the coating manufacturer's recommendations.

3.09. ON-SITE STORAGE

- A. If coated pipe, fittings, and associated components (i.e. flanges), are stored in direct sunlight resulting in chalking or other degradation, dry film thickness (DFT) measurements and adhesion tests shall be performed to ensure adequate coating thickness is achieved prior to installation. Do not store coated pipe in direct sunlight for a period greater than one (1) year.

END OF SECTION

SECTION 09 97 52

COLD-APPLIED WAX TAPE COATING

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials and application of a three-part, cold-applied wax tape coating system for buried piping per NACE SP0375 except as modified herein.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's catalog data sheets and application instructions.

PART 2 - MATERIALS

2.01. PRIMER

- A. Primer shall be a blend of petrolatums, plasticizers, and corrosion inhibitors having a paste-like consistency. The primer shall comply with NACE SP0375 and shall have the following properties:
 - 1. Pour Point: 100°F to 110°F.
 - 2. Flash Point: 350°F.
 - 3. Coverage: 1 gallon per 100 square feet.
- B. Primer shall be Trenton Wax Tape Primer, Denso Paste Primer, or equal.

2.02. WAX TAPE

- A. Wax tape shall consist of a synthetic-fiber felt, saturated with a blend of microcrystalline wax, petrolatum, plasticizers, and corrosion inhibitors, forming a tape coating that is easily formable over irregular surfaces. The tape shall comply with NACE SP0375 and shall have the following properties:
 - 1. Saturant Pour Point: 115°F to 120°F.
 - 2. Thickness: 50 to 70 mils.
 - 3. Tape Width: 6 inches.

- B. Wax tapes used for pipe soil-to-air transitions shall be UV light stable so as not to degrade in the presence of sunlight.
- C. Wax tape shall be Trenton No. 1 Wax Tape, Denso "Densyl Tape," or equal.

2.03. PLASTIC WRAPPER

- A. Wrapper shall be a polyvinylidene chloride plastic with three 50-gauge plies wound together as a single sheet. The wrapper shall have the following properties:
 - 1. Color: Clear.
 - 2. Thickness: 1.5 mils.
 - 3. Tape Width: 6 inches.
- B. Plastic wrapper shall be Trenton Poly-Ply, Denso Tape PVC Self-Adhesive, or equal.

2.04. POLYETHYLENE SHEET COATING

- A. See Section 09 97 06.

PART 3 - EXECUTION

3.01. WAX TAPE COATING APPLICATION

- A. Surfaces shall be clean and free of dirt, grease, water, and other foreign material prior to the application of the primer and wax tape.
- B. Apply primer by hand or brush to fitting surfaces. Work the primer into crevices and completely cover exposed metal surfaces.
- C. Apply the wax tape immediately after the primer application. Work the tape into the crevices around fittings. Apply the wax tape by pressing and molding the tape into conformity with the surface so that it does not bridge over irregular surfaces configurations. Begin wrapping approximately 3 inches behind the area to be wrapped. If starting at a straight edge, wrap the tape spirally around the pipe while touching the end edge before starting the angle to begin the spiral. If the previous roll is headed in a downward direction, tuck the next roll under the previous roll. Stretch each roll tight as wrapping continues to avoid air bubbles.
- D. Wrap the wax tape spirally around the pipe and across the fitting. Use a minimum overlap of 50% of the tape width. Apply tape to flanges, mechanical and restrained joint bolts, nuts and glands, and grooved-end couplings to 6 inches beyond each side of the item.

- E. Work the tape into the crevices and contours of irregularly shaped surfaces and smooth out so that there is a continuous protective layer with no voids or spaces under the tape.
- F. After application, seal the overlap seams of the tape by hand by tapering and pressing the seam, attempting to create a continuous surface. There shall be no air pockets underneath the tape. The tape shall have direct intimate contact with the pipe surface.
- G. On vertical sections of the piping, such as at pipe-to-soil transitions, wrap the pipe starting from the bottom and proceeding upward so that downward flowing water and backfill do not catch in a seam.
- H. Overwrap the completed wax tape installation with the plastic wrapping material. Wrap spirally around the pipe and across the fitting. Use a minimum overlap of 55% of the tape width and apply two layers or applications of overwrap. Secure plastic wrapper to pipe with adhesive tape.

3.02. POLYETHYLENE SHEET COATING TO BURIED PIPING

- A. Wrap completed wax tape coating system with polyethylene film per Section 09 97 06 and secure around the adjacent pipe circumference with adhesive tape.

3.03. HANDLING AND INSTALLING WAX-TAPE COATED PIPE

- A. Handle pipe in a manner to minimize damage to the coating. Equipment used for the handling of coated pipe shall be designed and constructed to avoid damaging the protective coating system. Inspect supported areas of the pipe prior to installation. Repair damaged areas before installation.
- B. The pipeline trench shall be free of rocks, foreign matter, and projections that could damage the coating system.

END OF SECTION

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SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.01. DESCRIPTION

- A. In general, these plans and specifications cover electrical connections to new equipment and controls as indicated on the plans and as required.

1.02. INTENT OF PLANS AND SPECIFICATIONS

- A. The intent of the plans and specifications is to prescribe a complete fully functional/operational new unit/facility or improvement to an existing facility which the CONTRACTOR undertakes to do, in full compliance with the intent of the plans, specifications, special provisions, approved change orders, and contract.
- B. The CONTRACTOR shall perform all work as provided and required in the plans, specifications, special provisions, approved change orders, addendums, and contract and shall do such additional, extra, and incidental work as may be required or considered necessary to complete the work in a thorough, complete, satisfactory, and acceptable manner.
- C. He shall furnish all labor, materials, tools, devices, fixtures, fasteners, equipment, conductors, transportation, and all incidentals and appurtenances necessary to the prosecution of the work and the completion of the fully operational unit, unless otherwise specified in writing.

1.03. SPECIAL PROVISIONS

- A. Should any work or any conditions or any equipment or device or any operation/function which are not thoroughly or satisfactorily stipulated or covered by the general or standard SPECIFICATIONS be anticipated on any proposed work, "Special Provisions" for such work may be prepared and shall be considered as a part of the specifications and contract. The CONTRACTOR shall perform all necessary testing.
- B. The CONTRACTOR'S responsibility shall be deemed to include the determination of the complete operational/functional intent of the plans and specifications and CONTRACTOR shall take no advantage of any error or omission in the plans and

specifications, and the ENGINEER shall be permitted to make any and such corrections or interpretations as may be deemed necessary for the fulfillment of the intent of the plans and specifications.

1.04. NEW EQUIPMENT REQUIRED

- A. All wiring, light fixtures, switches, and other wiring devices shall be new. All conduit shall be new (3/4" minimum) except for conduit to a single device or where approved by ENGINEER.

1.05. EQUIPMENT CONNECTION BY CONTRACTOR

- A. All equipment will be connected by a professionally licensed ELECTRICAL CONTRACTOR as required by the laws of the State of Colorado.

1.06. ELECTRICAL CONTRACTOR

- A. The ELECTRICAL CONTRACTOR shall furnish, deliver, erect, install, and connect complete for this project all the materials, power and control devices, wiring, wiring devices, receptacles, enclosures, disconnects, conduit, junction boxes, connectors, breakers, panelboards, control equipment and enclosures, pull boxes, protective underground tape, control conduit identification, terminating equipment, and any and all other devices, appurtenances and incidental materials and work necessary or which may be required to provide the desired fully functional/operational complete unit as defined and intended within the plans, drawings, specifications, written and verbal instructions which may be issued throughout the completion of this project.
- B. The ELECTRICAL CONTRACTOR shall closely inspect the work required of the other trades and shall be responsible for the ELECTRICAL POWER AND CONTROL CONNECTION TO EACH PIECE OF EQUIPMENT WHETHER HE SUPPLIED IT OR NOT, unless specifically stated otherwise elsewhere in the specifications. The ELECTRICAL CONTRACTOR shall coordinate closely with all others including any selected SUBCONTRACTORS, and provide all power wiring to the lighting systems, alarm, communications systems, monitoring systems, control systems, pump control panels, motors, SCADA, and pump equipment supplied or installed by all trades. Power and control wiring to all items shown on the electrical plans or indicated within the SPECIFICATIONS shall be installed in rigid steel conduit or IMC. Control conduit shall be installed by the ELECTRICAL CONTRACTOR. Control wiring and terminations shall be installed and terminated by a licensed and experienced ELECTRICAL CONTRACTOR familiar with control circuit wiring as a part of the instrumentation contract.

1.07. GENERAL CONDITIONS AND REQUIREMENTS

- A. The general requirements apply to all trades working on the project either working directly for the OWNER, for the GENERAL CONTRACTOR, a SUBCONTRACTOR, or a supplier.

1.08. CONTRACTOR FAMILIARITY WITH ALL SPECIFICATIONS

- A. The ELECTRICAL CONTRACTOR shall visit the site and familiarize himself with all portions of the work required and shown on the plans and in the specifications, including, but not limited to the ELECTRICAL specifications, the INSTRUMENTATION specifications, and all other equipment specifications for this project. The Instrumentation and Control Supplier or CONTRACTOR shall furnish detailed electrical connection diagrams of all motors, controls, communications, instrumentation, alarms, wiring, etc. to the ENGINEER for shop drawing approval. The instrumentation and control supplier and CONTRACTOR shall be responsible for all control wiring (complete) in conduit supplied by the ELECTRICAL CONTRACTOR.

1.09. RELATED WORK IN OTHER SECTIONS

- A. All work to be performed under this division of the plans and specifications shall be closely coordinated with all work required in other sections and divisions of the plans and specifications. The CONTRACTOR is encouraged to direct specific questions to the ENGINEER, prior to bidding, concerning any work to be performed or the intended operation of the devices he is to provide and install.

1.10. SHOP DRAWINGS, PRODUCT DATA, AND SAMPLES

- A. Shop Drawings, Product Data, and Samples: All are specified under general conditions and below. Any supposed conflicts in requirements of material to be purchased shall be brought to the attention of ENGINEER prior to bidding and such determination as made by him shall be used as a basis for bidding the project.

1.11. ORDINANCES, CODES AND PERMITS

- A. The CONTRACTOR shall keep himself informed fully on any and all local, State of Colorado, federal, and current applicable National Codes and Ordinances affecting this project and shall perform all work and install all devices and equipment in full compliance with said codes, ordinances, regulations, NECA, and OSHA.

- B. Should the specifications or plans conflict with such ordinances, laws, codes, or regulations, the conflicting portion of work affected by the conflict shall be installed in strict compliance with the applicable governing ordinance, code, law, or regulation mentioned above; the remainder of the plans and specifications, however, shall remain in full force and effect. In no case will work or materials inferior to those described on the plans and these specifications be accepted even if they satisfy the minimum standards of the governing code. All equipment shall be listed by Underwriters' Laboratories and bear the "U.L." label; all other equipment shall be specifically approved in writing by the ENGINEER prior to installation.

1.12. STANDARDS

- A. Any reference in the plans or specifications to any article, device, product, material, fixture, form, or type of construction by name, manufacturer, make, model, or catalog number, shall be interpreted as establishing a minimum standard of quality and shall not be construed as limiting competition.

1.13. PERMITS AND FEES

- A. It shall be the responsibility of any SUBCONTRACTOR to obtain all necessary licenses or permits lawfully required, and to pay all charges or fees related thereto, including approval certificates and inspection fee and give all notices necessary and incidental to the due and lawful prosecution of the work including those established by ordinances.

1.14. SITE OBSERVATIONS

- A. Periodic site observations will be made to assure compliance of the work with the plans and specifications. The CONTRACTOR shall furnish the OWNER / ENGINEER with every reasonable facility for ascertaining whether or not the work was performed in accordance with the requirements and intents of the plans and specifications. CONTRACTOR shall provide all assistance necessary or required by the ENGINEER.

1.15. PRODUCTS

- A. The CONTRACTOR shall furnish products specified or required for proper operation of the items, devices, subsystems, and systems indicated on the plans or in the SPECIFICATIONS.

1.16. DRAWINGS, WORK LAYOUT AND EXECUTION

- A. The plans indicate only a general schematic arrangement and layout of conduit and wiring. Detailed shop drawings indicating point-to-point connection of all instrumentation and control systems, motor starters, and control layouts shall be prepared by the CONTRACTOR and submitted to the ENGINEER for approval. These drawings shall show exact placement of control conduit and wire ways, wire, and equipment, along with the type, model, size, mode, etc. of the equipment required to make the systems operate as designed by the manufacturer and/ or as specified in the plans, specifications, and the contract documents, or as directed, in writing, by the ENGINEER.

1.17. WORKMANSHIP

- A. All work shall be performed in a thorough and competent workmanlike manner in accordance with the plans, specifications, construction drawings, change orders, and manufacturer's drawings utilizing the highest quality of standard practices acceptable within the electrical industry and in accordance with NECA standards.

1.18. SHOP DRAWING SUBMITTALS AND EQUIPMENT

- A. The ELECTRICAL CONTRACTOR shall submit six (6) copies of shop drawings to the ENGINEER for approval. The drawings shall include a schedule (list) of all materials and equipment that shall be clearly identified showing the following: The device designating symbol for easy location; the manufacturer, catalog number, model number, voltage, current, wattage and all information which may be necessary to evaluate the item proposed; general mounting or installation data, where device is proposed to be installed. All similar items shall be grouped together (i.e., motors, light fixtures, panelboards (with circuit breakers), disconnect switches, starters, and etc). The CONTRACTOR shall clearly designate each item to ensure easy correlation between the list of materials and equipment shown on the shop drawings and those submitted by the equipment supplier referred to in section 26 05 00 - 1.19 below. All shop drawings required shall be submitted at one time. No consideration will be given to incomplete shop drawings. The drawings shall identify any and all proposed materials not in compliance with the plans and specifications and a transmittal letter shall outline reasons for non-compliance. No equipment shall be ordered until shop drawings have been approved by the ENGINEER. Approval, when given, shall not relieve CONTRACTOR, equipment vendor (supplier), or manufacturer from the responsibility to provide a fully operational/functional system (in local and remote) as defined by the

OWNER / ENGINEER in the plans and specifications; nor shall this approval relieve the CONTRACTOR, vendor, or manufacturer of any responsibility for proper function resulting from any errors or omissions.

1.19. EQUIPMENT VENDOR (SUPPLIER) SUBMITTALS

- A. The equipment supplier (vendor) shall furnish the type of equipment generally specified on these plans and defined in the specifications. The equipment supplier shall provide submittals in bound volumes in the same numerical order of the specification starting with Section 26 05 00. The equipment shall include but not be limited to: Raceways, conductors, outlet boxes, cabinets, panelboards, switches, receptacles, motor starters, disconnects, overcurrent protective fuses, circuit breakers, overloads, electronic devices, transformers, grounding devices, distribution equipment, lighting fixtures, lamps, ballasts, standards, communication equipment, and control cabinets, alarms, contactors, hoists, device controllers, indicator, solenoids, thermostats, fans, heaters, dampers and all other required devices including but not limited to motor controls, phase reversal, surge and spike protection. SURGE PROTECTION AND PHASE REVERSAL OR LOSS PROTECTION IS REQUIRED IN ALL SERVICE ENTRANCE EQUIPMENT WHETHER SHOWN ON THE PLANS OR NOT and shall protect the attached motors by removing them from the line if phase reversal, phase loss, or a damaging voltage surge is experienced until such condition is corrected or device replaced.

1.20. SUBSTITUTIONS

- A. If the ELECTRICAL CONTRACTOR wishes to submit, for approval, a piece of equipment different from the one specifically shown on the plans, he may do so provided that the equipment is fully equal or superior to that shown. The specific brands and models shown are to be used as a minimum standard of performance, quality, and operation. It is not the intent of these plans and specifications to limit competition in any way between qualified vendors and material suppliers by requiring that a certain manufacturer's equipment be furnished. However, in order to pre-qualify equipment and thus validate assumptions made in assembling his bid, the supplier shall contact the ENGINEER no later than ten (10) working days prior to bid date and demonstrate the suitability of the proposed substitution. Manufacturer's cut sheets, and in some cases, samples must be supplied if required by the ENGINEER. ENGINEER shall determine acceptability.

1.21. DELIVERY, HANDLING, STORAGE AND MARKING

- A. Upon receiving any/all electrical equipment, devices, components, fixtures, wiring, cable, or other appurtenances to be furnished and installed on this project, the CONTRACTOR shall take all necessary caution to receive, unload, stack, store, and protect them from water and other potentially harmful elements. All devices and equipment must be stored indoors at all times, unless prior approval, in writing, is given by the OWNER / ENGINEER.
- B. All devices, equipment and components must be shipped in structurally adequate packages and/or containers. All shipping containers shall be permanently and clearly marked or tagged to identify its contents properly and clearly.
- C. All devices, equipment and components must be stored, moved, transported, opened, and installed using equipment, tools, and devices adequate and manufactured for the purpose.
- D. The CONTRACTOR shall store all devices, equipment, wire, appurtenances, and components in their original, unopened, shipping packages as received from the manufacturer or materials vendor.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01. AS-BUILT DRAWINGS

- A. Upon completion, one (1) set of reproducible and two (2) bound copies of "As-Built Drawings", along with two (2) bound sets of all instructions, operation and maintenance manuals, warranties, guarantees, spare parts, of all equipment shall be submitted for review by the ENGINEER. As-Built Drawings will reflect and record any and all changes made and recorded on jobsite updated drawings. During construction, the two (2) sets of "red marked drawings" shall be kept indicating ANY changes on the plans required during construction. One shall be kept on the job with the other set being updated weekly showing such changes. It is specifically required that the location (with exact dimensions) of all under floor conduit or concealed feeders be noted. Electrical circuit numbers shall be exactly like that shown on the electrical

plans. No unnecessary splices shall be made in panelboards to accommodate incorrect wire lengths. Upon review and approval of submitted As-Built drawings and Operation and Maintenance Manuals, materials and information, the CONTRACTOR shall assemble and submit the required number of completed Operation and Maintenance Manuals to the ENGINEER.

3.02. TEST OF COMPLETED WORK

- A. After the work is completed and all equipment installed, and before initial use, operational tests of the electrical system and equipment shall be performed in both local and remote operation. Commissioning tests shall include the operation of every switch, plant sequence for start, run and shut down, indicator, control, alarm, motor starter, fixture, breaker, panelboard, motor, and all special equipment.
- B. The resistance to ground of the system conductors shall be measured with a "megger" from existing main switch or power busses to ground (a resistance greater than 10 MEG is required); resistance shall be measured from the main bus to each panel with the main breaker open, and grounding bus open. (A maximum grounding electrode system resistance of 10 ohms is acceptable).
- C. Also, after installation of the instrumentation, monitoring and control conduit and wire, the installation shall be checked by the INSTRUMENTATION CONTRACTOR for wire types, faults and other factors which might influence the accuracy or reliability of the instrumentation system specified. If any problems in the installation of the instrument wiring are discovered by the INSTRUMENTATION CONTRACTOR, they shall be reported to the appropriate contracting agent or officer who, in turn, shall direct the changes necessary for the proper function of the instrumentation system, at no additional cost to the OWNER.

3.03. EQUIPMENT GUARANTEE

- A. The ELECTRICAL CONTRACTOR shall warranty and guarantee all components furnished and installed against defects of workmanship or materials for one year, twelve (12) months, from date of written "Notice of Acceptance" by the OWNER. The ELECTRICAL CONTRACTOR shall, upon notice of such failure, promptly repair or replace the defective item without cost to the OWNER.

END OF SECTION

SECTION 26 05 03

UTILITY COORDINATION

PART 1 - GENERAL

1.01. SUMMARY

- A. This Section includes requirements for coordination with electric utility companies for permanent electrical service, including but not limited to:
 - 1. Service applications and approvals
 - 2. Utility company coordination meetings
 - 3. Utility-owned equipment interfaces
 - 4. Service energization scheduling
 - 5. Temporary service coordination, if required
- B. Work under this Section applies to all electrical services connected to utility-owned distribution systems.

1.02. REFERENCES

- A. National Electrical Code (NEC), latest adopted edition
- B. National Electrical Safety Code (NESC)
- C. Utility company service standards and requirements
- D. Local Authority Having Jurisdiction (AHJ) requirements

1.03. SUBMITTALS

- A. Informational Submittals:
 - 1. Utility service applications
 - 2. Utility correspondence and approvals
 - 3. Utility service drawings and sketches

- 4. Utility construction schedules
- B. Closeout Submittals:
 - 1. Final utility approval documentation
 - 2. Utility service acceptance or energization confirmation
- 1.04. QUALITY ASSURANCE
 - A. Utility coordination shall be performed by personnel experienced in coordinating electrical services with the serving utility.
 - B. All utility interfaces shall comply with the latest published utility standards and NEC requirements.
- 1.05. COORDINATION
 - A. Coordinate work of this Section with:
 - 1. Division 01 – General Requirements
 - 2. Division 26 – Electrical Sections
 - 3. Civil site work and underground utilities
 - B. Coordinate service point locations, metering requirements, transformer ownership, and service voltage with the serving utility.

PART 2 - PRODUCTS

- 2.01. GENERAL
 - A. Products furnished by the utility company are not included in this Section.
 - B. Contractor-furnished equipment interfacing with utility systems shall comply with utility standards and project specifications.

PART 3 - EXECUTION

3.01. UTILITY COORDINATION RESPONSIBILITIES

- A. Coordinate all aspects of permanent electrical service with the serving utility, including:
 - 1. Service application and fees
 - 2. Utility reviews and approvals
 - 3. Scheduling of utility construction
 - 4. Final service energization
- B. Confirm service voltage, fault current, metering requirements, and point of delivery prior to equipment installation.

3.02. SERVICE APPLICATION

- A. Submit all required service applications to the utility company in a timely manner.
- B. Provide load calculations, one-line diagrams, and site plans as required by the utility.

3.03. UTILITY MEETINGS

- A. Attend utility coordination meetings as required to review service requirements, schedules, and responsibilities.
- B. Document all coordination meetings and provide meeting notes to the Engineer upon request.

3.04. INTERFACE WITH UTILITY EQUIPMENT

- A. Install all contractor-owned equipment up to the utility-defined point of delivery.
- B. Maintain required clearances and access to utility-owned equipment.
- C. Do not modify or connect to utility-owned equipment without written authorization from the utility.

3.05. SCHEDULING AND ENERGIZATION

- A. Coordinate construction schedules with the utility to ensure timely service availability.

- B. Notify the utility in advance of readiness for service inspection and energization.
- C. Provide all required inspections and approvals prior to energization.

3.06. TEMPORARY SERVICE (IF REQUIRED)

- A. Coordinate temporary electrical service with the utility when indicated.
- B. Temporary service shall comply with utility standards and NEC requirements.
- C. Remove temporary service equipment when no longer required.

3.07. FIELD QUALITY CONTROL

- A. Correct deficiencies identified by the utility or AHJ prior to energization.
- B. Provide access for utility inspection as required.

3.08. CLOSEOUT

- A. Submit final utility approvals and energization documentation.
- B. Verify permanent service is operational prior to project closeout.

END OF SECTION

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Single conductor building wire.
- B. Underground feeder and branch-circuit cable.
- C. Wiring connectors.
- D. Wire pulling lubricant.
- E. Cable ties.

1.02. RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.
- B. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.

1.03. REFERENCE STANDARDS

- A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire; 2013 (Reapproved 2024).
- B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft; 2023.
- C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes; 2010, with Editorial Revision (2020).
- D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation; 2004 (Reapproved 2020).
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.

- F. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy; 2021.
- G. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- H. UL 44 - Thermoset-Insulated Wires and Cables; Current Edition, Including All Revisions.
- I. UL 83 - Thermoplastic-Insulated Wires and Cables; Current Edition, Including All Revisions.
- J. UL 267 - Outline of Investigation for Wire-Pulling Compounds; Current Edition, Including All Revisions.
- K. UL 486A-486B - Wire Connectors; Current Edition, Including All Revisions.
- L. UL 486C - Splicing Wire Connectors; Current Edition, Including All Revisions.
- M. UL 493 - Thermoplastic-Insulated Underground Feeder and Branch-Circuit Cables; Current Edition, Including All Revisions.

1.04. ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
 - 3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05. SUBMITTALS

- A. See Section 01 33 00 - Submittals, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and available sizes, configurations, and stranding.

1.06. QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

PART 2 - PRODUCTS

2.01. CONDUCTOR AND CABLE APPLICATIONS

- A. Do not use conductors and cables for applications other than as permitted by NFPA 70 and product listing.
- B. Provide single conductor building wire installed in suitable raceway unless otherwise indicated, permitted, or required.

2.02. CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- D. Comply with NEMA WC 70.
- E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- G. Conductor Material:
 - 1. Provide copper conductors only. Aluminum conductors are not acceptable for this project. Conductor sizes indicated are based on copper.
 - 2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
 - 3. Tinned Copper Conductors: Comply with ASTM B33.

H. Conductor Color Coding:

1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
2. Color Coding Method: Integrally colored insulation.
3. Color Code:
 - a. 208Y/120 V, 3 Phase, 4 Wire System:
 - (1) Phase A: Black.
 - (2) Phase B: Red.
 - (3) Phase C: Blue.
 - (4) Neutral/Grounded: White.
 - b. 240/120 V High-Leg Delta, 3 Phase, 4 Wire System:
 - (1) Phase A: Black.
 - (2) Phase B (High-Leg): Orange.
 - (3) Phase C: Blue.
 - (4) Neutral/Grounded: White.
 - c. 240/120 V, 1 Phase, 3 Wire System:
 - (1) Phase A: Black.
 - (2) Phase B: Red.
 - (3) Neutral/Grounded: White.
 - d. Equipment Ground, All Systems: Green.

2.03. SINGLE CONDUCTOR BUILDING WIRE

- A. Description: Single conductor insulated wire.
- B. Conductor Stranding:

1. Feeders and Branch Circuits: Stranded.
- C. Insulation Voltage Rating: 600 V.
- D. Insulation:
 1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.

2.04. UNDERGROUND FEEDER AND BRANCH-CIRCUIT CABLE

- A. Manufacturers:
 1. Cerro Wire LLC: www.cerrowire.com/#sle.
 2. Southwire Company: www.southwire.com/#sle.
- B. Description: NFPA 70, Type UF multiple-conductor cable listed and labeled as complying with UL 493, Type UF-B.
- C. Provide equipment grounding conductor unless otherwise indicated.
- D. Insulation Voltage Rating: 600 V.

2.05. WIRING CONNECTORS

- A. Description: Wiring connectors appropriate for the application, suitable for use with the conductors to be connected, and listed as complying with UL 486A-486B or UL 486C as applicable.

2.06. ACCESSORIES

- A. Wire Pulling Lubricant:
 1. Manufacturers:
 - a. 3M: www.3m.com/#sle.
 - b. American Polywater Corporation: www.polywater.com/#sle.
 - c. Ideal Industries, Inc: www.idealindustries.com/#sle.
 2. Listed and labeled as complying with UL 267.

3. Suitable for use with conductors/cables and associated insulation/jackets to be installed; approved by conductor/cable manufacturer.
 4. Suitable for use at installation temperature.
- B. Cable Ties: Material and tensile strength rating suitable for application.

PART 3 - EXECUTION

3.01. EXAMINATION

- A. Verify that work likely to damage wire and cable has been completed.
- B. Verify that raceways, boxes, and equipment enclosures are installed and are properly sized to accommodate conductors and cables in accordance with NFPA 70.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02. PREPARATION

- A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

3.03. INSTALLATION

- A. Circuiting Requirements:
 1. Unless dimensioned, circuit routing indicated is diagrammatic.
 2. When circuit destination is indicated without specific routing, determine exact routing required.
 3. Arrange circuiting to minimize splices.
- B. Install products in accordance with manufacturer's instructions.
- C. Perform work in accordance with NECA 1 (general workmanship).
- D. Installation in Raceway:
 1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.

2. Pull all conductors and cables together into raceway at same time.
 3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
 4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
- E. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- F. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
- G. Terminate cables using suitable fittings.
- H. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.
- I. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
- J. Make wiring connections using specified wiring connectors.
1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
 2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
 3. Do not remove conductor strands to facilitate insertion into connector.
 4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminates. Do not use wire brush on plated connector surfaces.
- K. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.

- L. Insulate ends of spare conductors using vinyl insulating electrical tape.
- M. Unless specifically indicated to be excluded, provide final connections to all equipment and devices, including those furnished by others, as required for a complete operating system.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground bars.
- E. Ground rod electrodes.
- F. Ground access wells.

1.02. RELATED REQUIREMENTS

- A. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables: Additional requirements for conductors for grounding and bonding, including conductor color coding.
- B. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.

1.03. REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- B. NEMA GR 1 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings; 2022.
- C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. UL 467 - Grounding and Bonding Equipment; Current Edition, Including All Revisions.

1.04. ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. Verify exact locations of underground metal water service pipe entrances to building.
2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
3. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.05. SUBMITTALS

- A. See Section 01 33 00 - Submittals for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for grounding and bonding system components.
- C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.06. QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.07. DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.01. GROUNDING AND BONDING REQUIREMENTS

- A. Do not use products for applications other than as permitted by NFPA 70 and product listing.
- B. Unless specifically indicated to be excluded, provide all required components, conductors, connectors, conduit, boxes, fittings, supports, accessories, etc. as necessary for a complete grounding and bonding system.
- C. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- D. Bonding and Equipment Grounding:
 - 1. Provide bonding for equipment grounding conductors, equipment ground busses, metallic equipment enclosures, metallic raceways and boxes, device grounding terminals, and other normally non-current-carrying conductive materials enclosing electrical conductors/equipment or likely to become energized as indicated and in accordance with NFPA 70.
 - 2. Raceways may be used as sole equipment grounding conductor where permitted by NFPA 70. Provide insulated equipment grounding conductor where indicated or required, including but not limited to:
 - a. In each nonmetallic feeder and branch circuit raceway.
 - b. In each flexible conduit.
 - c. In outdoor portions of each metallic feeder and branch circuit raceway utilizing non-threaded fittings (where permitted) supplying rooftop multimotor and combination-load air-conditioning and refrigerating equipment.
 - 3. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
 - 4. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.

5. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
6. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.

2.02. GROUNDING AND BONDING COMPONENTS

A. General Requirements:

1. Provide products listed, classified, and labeled as suitable for the purpose intended.
2. Provide products listed and labeled as complying with UL 467 where applicable.

B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 26 05 26:

1. Use insulated copper conductors unless otherwise indicated.
 - a. Exceptions:
 - (1) Use bare copper conductors where installed underground in direct contact with earth.
 - (2) Use bare copper conductors where directly encased in concrete (not in raceway).

C. Connectors for Grounding and Bonding:

1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
3. Unless otherwise indicated, use mechanical connectors, compression connectors, or exothermic welded connections for accessible connections.

D. Ground Bars:

1. Description: Copper rectangular ground bars with mounting brackets and insulators.
2. Size: As indicated.
3. Holes for Connections: As indicated or as required for connections to be made.

E. Ground Rod Electrodes:

1. Comply with NEMA GR 1.
2. Material: Copper-bonded (copper-clad) steel.
3. Size: 3/4 inch (19 mm) diameter by 10 feet (3.0 m) length, unless otherwise indicated.

F. Ground Access Wells:

1. Description: Open bottom round or rectangular well with access cover for testing and inspection; suitable for the expected load at the installed location.
2. Size: As required to provide adequate access for testing and inspection, but not less than minimum size requirements specified.
3. Depth: As required to extend below frost line to prevent frost upheaval, but not less than 10 inches (250 mm).
4. Cover: Factory-identified by permanent means with word "GROUND".

PART 3 - EXECUTION

3.01. EXAMINATION

- A. Verify that work likely to damage grounding and bonding system components has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02. INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70 or provide ground plates.
 - 1. Outdoor Installations: Unless otherwise indicated, install with top of rod 6 inches (150 mm) below finished grade.
- D. Make grounding and bonding connections using specified connectors.
 - 1. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors. Do not remove conductor strands to facilitate insertion into connector.
 - 2. Remove nonconductive paint, enamel, or similar coating at threads, contact points, and contact surfaces.
 - 3. Exothermic Welds: Make connections using molds and weld material suitable for the items to be connected in accordance with manufacturer's recommendations.
 - 4. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
 - 5. Compression Connectors: Secure connections using manufacturer's recommended tools and dies.
- E. Identify grounding and bonding system components in accordance with Section 26 05 53.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other electrical work.

1.02. RELATED REQUIREMENTS

- A. Section 26 05 33 - Conduit for Electrical Systems: Additional support and attachment requirements for conduits.

1.03. REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products; 2024.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware; 2023.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel; 2023.
- D. MFMA-4 - Metal Framing Standards Publication; 2004.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.04. ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with actual equipment and components to be installed.

2. Coordinate work to provide additional framing and materials required for installation.
3. Coordinate compatibility of support and attachment components with mounting surfaces at installed locations.
4. Coordinate arrangement of supports with ductwork, piping, equipment and other potential conflicts.
5. Notify Engineer of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05. SUBMITTALS

- A. See Section 01 33 00 - Submittals for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel/strut framing systems and post-installed concrete/masonry anchors.

1.06. DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.01. SUPPORT AND ATTACHMENT COMPONENTS

- A. General Requirements:
 1. Comply with the following. Where requirements differ, comply with most stringent.
 - a. NFPA 70.
 - b. Requirements of authorities having jurisdiction.
 2. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of electrical work.
 3. Provide products listed, classified, and labeled as suitable for purpose intended, where applicable.

4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for load to be supported. Include consideration for vibration, equipment operation, and shock loads where applicable.
 5. Do not use products for applications other than as permitted by NFPA 70 and product listing.
 6. Steel Components: Use corrosion-resistant materials suitable for environment where installed.
 - a. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - b. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - c. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.
- B. Conduit and Cable Supports: Straps and clamps suitable for conduit or cable to be supported.
1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
 2. Conduit Clamps: Bolted type unless otherwise indicated.
- C. Outlet Box Supports: Hangers and brackets suitable for boxes to be supported.
- D. Metal Channel/Strut Framing Systems:
1. Description: Factory-fabricated, continuous-slot, metal channel/strut and associated fittings, accessories, and hardware required for field assembly of supports.
 2. Comply with MFMA-4.
 3. Channel Material:
 - a. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel.
- E. Hanger Rods: Threaded, zinc-plated steel unless otherwise indicated.
- F. Anchors and Fasteners:

1. Unless otherwise indicated and where not otherwise restricted, use anchor and fastener types indicated for specified applications.

PART 3 - EXECUTION

3.01. EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive support and attachment components.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02. INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install hangers and supports in accordance with NECA 1.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D. Equipment Support and Attachment:
 1. Use metal, fabricated supports or supports assembled from metal channel/strut to support equipment as required.
 2. Use metal channel/strut secured to studs to support equipment surface mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 3. Use metal channel/strut to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- E. Secure fasteners in accordance with manufacturer's recommended torque settings.
- F. Remove temporary supports.

3.03. FIELD QUALITY CONTROL

- A. Inspect support and attachment components for damage and defects.
- B. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- C. Correct deficiencies and replace damaged or defective support and attachment components.

END OF SECTION

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SECTION 26 05 33

CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Galvanized steel rigid metal conduit (RMC).
- B. Stainless steel rigid metal conduit (RMC).
- C. Galvanized steel intermediate metal conduit (IMC).
- D. Stainless steel intermediate metal conduit (IMC).
- E. PVC-coated galvanized steel rigid metal conduit (RMC).
- F. Liquidtight flexible metal conduit (LFMC).
- G. Galvanized steel electrical metallic tubing (EMT).
- H. Rigid polyvinyl chloride (PVC) conduit.

1.02. RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- C. Section 26 05 53 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 31 23 43 – Trenching, Backfilling, and Compacting

1.03. REFERENCE STANDARDS

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC); 2025.
- B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S); 2020.

- C. ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit; 2025.
- D. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- E. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT); 2020.
- F. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC); 2025.
- G. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable; 2014.
- H. NEMA RN 1 - Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Metal Conduit and Intermediate Metal Conduit; 2018.
- I. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit; 2020.
- J. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing; 2021.
- K. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- L. UL 6 - Electrical Rigid Metal Conduit-Steel; Current Edition, Including All Revisions.
- M. UL 6A - Electrical Rigid Metal Conduit-Aluminum, Red Brass, and Stainless Steel; Current Edition, Including All Revisions.
- N. UL 360 - Liquid-Tight Flexible Metal Conduit; Current Edition, Including All Revisions.
- O. UL 514A - Metallic Outlet Boxes; Current Edition, Including All Revisions.
- P. UL 514B - Conduit, Tubing, and Cable Fittings; Current Edition, Including All Revisions.
- Q. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings; Current Edition, Including All Revisions.
- R. UL 797 - Electrical Metallic Tubing-Steel; Current Edition, Including All Revisions.
- S. UL 1242 - Electrical Intermediate Metal Conduit-Steel; Current Edition, Including All Revisions.

- T. UL 2419 - Outline of Investigation for Electrically Conductive Corrosion Resistant Compounds; Current Edition, Including All Revisions.

1.04. ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate minimum sizes of conduits with actual type and quantity of conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
2. Coordinate arrangement of conduits with structural members, ductwork, piping, equipment, and other potential conflicts.
3. Verify exact conduit termination locations required for boxes, enclosures, and equipment.
4. Coordinate work to provide roof penetrations that preserve integrity of roofing system and do not void roof warranty.
5. Notify Architect of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not begin installation of conductors and cables until installation of conduit between termination points is complete.

1.05. SUBMITTALS

- A. See Section 01 33 00 - Submittals for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conduits and fittings.

1.06. DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store conduit and fittings in accordance with manufacturer's instructions.

PART 2 - PRODUCTS

2.01. CONDUIT APPLICATIONS

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70, manufacturer's instructions, and product listing.
- B. Unless otherwise indicated and where not otherwise restricted, use conduit types indicated for specified applications. Where more than one listed application applies, comply with most restrictive requirements. Where conduit type for particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
 - 1. Where rigid polyvinyl chloride (PVC) conduit is provided, transition to galvanized steel rigid metal conduit (RMC) where emerging from underground.
 - 2. Where galvanized steel rigid metal conduit (RMC) or galvanized steel intermediate metal conduit (IMC) is installed in direct contact with earth where soil has resistivity of less than 2000 ohm-centimeters or is characterized as severely corrosive based on soils report or local experience, use corrosion protection tape, factory-applied corrosion protection coating, or field-applied corrosion protection compound acceptable to authorities having jurisdiction to provide supplementary corrosion protection.
 - 3. Where galvanized rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), or galvanized steel electrical metallic tubing (EMT) emerges from concrete into soil, use corrosion protection tape, factory-applied corrosion protection coating, or field-applied corrosion protection compound acceptable to authorities having jurisdiction to provide supplementary corrosion protection for minimum of 4 inches (100 mm) on either side of where conduit emerges.
- D. Embedded Within Concrete:
 - 1. Within Slab on Grade: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal conduit (RMC), galvanized steel electrical metallic tubing (EMT), rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC). Embed within structural slabs only where approved by Structural Engineer.

2. Within Slab Above Ground: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal conduit (RMC), galvanized steel electrical metallic tubing (EMT), rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC). Embed within structural slabs only where approved by Structural Engineer.
3. Where rigid polyvinyl (PVC) conduit is provided, transition to galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), or galvanized steel electrical metallic tubing (EMT) where emerging from concrete.

2.02. CONDUIT - GENERAL REQUIREMENTS

- A. Comply with NFPA 70.
- B. Provide conduit, fittings, supports, and accessories required for complete raceway system.
- C. Provide products listed, classified, and labeled as suitable for purpose intended.
- D. Minimum Conduit Size, Unless Otherwise Indicated:
 1. Branch Circuits: 3/4-inch (21 mm) trade size.
 2. Underground, Exterior: 1-inch (27 mm) trade size.
- E. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.03. GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- B. Fittings:
 1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6.

2. Material: Use steel or malleable iron.
3. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

2.04. STAINLESS STEEL RIGID METAL CONDUIT (RMC)

- A. Description: NFPA 70, Type RMC stainless steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6A.
- B. Fittings:
 1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6A.
 2. Material: Use stainless steel with corrosion resistance equivalent to conduit.
 3. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

2.05. GALVANIZED STEEL INTERMEDIATE METAL CONDUIT (IMC)

- A. Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- B. Fittings:
 1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 1242.
 2. Material: Use steel or malleable iron.
 3. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

2.06. STAINLESS STEEL INTERMEDIATE METAL CONDUIT (IMC)

- A. Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- B. Fittings:

1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 1242.

2.07. PVC-COATED GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit with external polyvinyl chloride (PVC) coating complying with NEMA RN 1 and listed and labeled as complying with UL 6.
- B. Exterior Coating: Polyvinyl chloride (PVC), nominal thickness of 40 mil, 0.040 inch (1.02 mm).
- C. PVC-Coated Boxes and Fittings:
 1. Manufacturer: Same as manufacturer of PVC-coated conduit to be installed.
 2. Nonhazardous Locations: Use boxes and fittings listed and labeled as complying with UL 514A, UL 514B, or UL 6.
 3. Material: Use steel or malleable iron.
 4. Exterior Coating: Polyvinyl chloride (PVC), minimum thickness of 40 mil, 0.040 inch (1.02 mm).
- D. PVC-Coated Supports: Furnish with exterior coating of polyvinyl chloride (PVC), minimum thickness of 15 mil, 0.015 inch (0.38 mm).

2.08. LIQUIDTIGHT FLEXIBLE METAL CONDUIT (LFMC)

- A. Description: NFPA 70, Type LFMC polyvinyl chloride (PVC) jacketed steel flexible metal conduit listed and labeled as complying with UL 360.
- B. Fittings:
 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 2. Material: Use steel or malleable iron.

2.09. GALVANIZED STEEL ELECTRICAL METALLIC TUBING (EMT)

- A. Description: NFPA 70, Type EMT galvanized steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.

B. Fittings:

1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
2. Material: Use steel or malleable iron.
3. Connectors and Couplings: Use compression/gland or set-screw type.
 - a. Do not use indenter type connectors and couplings.
4. Damp or Wet Locations, Where Permitted: Use fittings listed for use in wet locations.
5. Embedded Within Concrete, Where Permitted: Use fittings listed as concrete-tight. Fittings that require taping to be concrete-tight are acceptable.

2.10. RIGID POLYVINYL CHLORIDE (PVC) CONDUIT

- A. Description: NFPA 70, Type PVC rigid polyvinyl chloride conduit complying with NEMA TC 2 and listed and labeled as complying with UL 651; Schedule 80 unless otherwise indicated; rated for use with conductors rated 90 degrees C.

2.11. FITTINGS

- A. Manufacturer: Same as manufacturer of conduit to be connected.
- B. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.

2.12. ACCESSORIES

- A. Corrosion Protection Tape: PVC-based, minimum thickness of 20 mil, 0.020 inch (0.51 mm).
- B. Conduit Joint Compound: Corrosion-resistant, electrically conductive compound listed as complying with UL 2419; suitable for use with conduit to be installed.
- C. Solvent Cement for PVC Conduit and Fittings: As recommended by manufacturer of conduit and fittings to be installed.
- D. Pull Strings: Use nylon or polyester tape with average breaking strength of not less than 1,250 lbf (5.6 kN).

- E. Conduit Mechanical Seals:
 - 1. Listed as complying with UL 514B.
 - 2. Specifically designed for sealing conduit openings against water, moisture, gases, and dust.
 - 3. Suitable for sealing around conductors/cables to be installed.
- F. Sealing Systems for Concrete Penetrations:
 - 1. Sleeves: Provide water stop ring or cement coating that bonds to concrete to prevent water infiltration.
 - 2. Rate for minimum of 40 psig; suitable for sealing around conduits to be installed.

PART 3 - EXECUTION

3.01. EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that mounting surfaces are ready to receive conduits.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02. INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install conduit in accordance with NECA 1.
- C. Galvanized Steel Rigid Metal Conduit (RMC): Install in accordance with NECA 101.
- D. Intermediate Metal Conduit (IMC): Install in accordance with NECA 101.
- E. PVC-Coated Galvanized Steel Rigid Metal Conduit (RMC): Install using only tools approved by manufacturer.
- F. Rigid Polyvinyl Chloride (PVC) Conduit: Install in accordance with NECA 111.
- G. Conduit Support:

1. Secure and support conduits in accordance with NFPA 70 using suitable supports and methods approved by authorities having jurisdiction; see Section 26 05 29.
2. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
3. Use metal channel/strut with accessory conduit clamps to support multiple parallel surface-mounted conduits.
4. Use conduit clamp to support single conduit from beam clamp or threaded rod.

H. Connections and Terminations:

1. Use approved zinc-rich paint or conduit joint compound on field-cut threads of galvanized steel conduits prior to making connections.
2. Where two threaded conduits must be joined and neither can be rotated, use three-piece couplings or split couplings. Do not use running threads.
3. Use suitable adapters where required to transition from one type of conduit to another.
4. Provide drip loops for liquidtight flexible conduit connections to prevent drainage of liquid into connectors.
5. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
6. Provide insulating bushings, insulated throats, or listed metal fittings with smooth, rounded edges at conduit terminations to protect conductors.
7. Secure joints and connections to provide mechanical strength and electrical continuity.

I. Penetrations:

1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
2. Make penetrations perpendicular to surfaces unless otherwise indicated.

3. Provide sleeves for penetrations as indicated or as required to facilitate installation. Set sleeves flush with exposed surfaces unless otherwise indicated or required.
 4. Conceal bends for conduit risers emerging above ground.
 5. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
- J. Underground Installation:
1. Provide trenching and backfilling; see Section 31 23 43.
 2. Minimum Cover, Unless Otherwise Indicated or Required:
 - a. Underground, Exterior: 18 inches (460 mm).
 - b. Under Slab on Grade: 12 inches (300 mm) to bottom of slab.
 3. Provide underground warning tape along entire conduit length for service entrance where not concrete-encased; see Section 26 05 53.
- K. Embedment Within Structural Concrete Slabs (only where approved by Structural Engineer):
1. Maximum Conduit Size: 1-inch (27 mm) trade size unless otherwise approved.
 2. Install conduits within middle one third of slab thickness.
 3. Secure conduits to prevent floating or movement during pouring of concrete.
- L. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings or approved flexible connections to prevent damage to enclosed conductors or connected equipment. This includes, but is not limited to:
1. Where conduits cross structural joints intended for expansion, contraction, or deflection.
 2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.

3. Where conduits are subject to earth movement by settlement or frost.

M. Conduit Sealing:

1. Use foam conduit sealant to prevent entry of moisture and gases. This includes, but is not limited to:
 - a. Where conduits enter building from outside.
 - b. Where service conduits enter building from underground distribution system.
 - c. Where conduits enter building from underground.
 - d. Where conduits may transport moisture to contact live parts.

- N. Provide grounding and bonding; see Section 26 05 26.

3.03. FIELD QUALITY CONTROL

- A. Repair cuts and abrasions in galvanized finishes using zinc-rich paint recommended by manufacturer. Replace components that exhibit signs of corrosion.
- B. Where coating of PVC-coated galvanized steel rigid metal conduit (RMC) contains cuts or abrasions, repair in accordance with manufacturer's instructions.
- C. Correct deficiencies and replace damaged or defective conduits.

3.04. CLEANING

- A. Clean interior of conduits to remove moisture and foreign matter.

3.05. PROTECTION

- A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of conductors.

END OF SECTION

SECTION 26 05 34

SURFACE RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Surface raceway systems.

1.02. RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- C. Section 26 05 33 - Conduit for Electrical Systems.

1.03. REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- B. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.

1.04. ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of raceways with millwork, furniture, equipment, etc. installed under other sections or by others.
 - 2. Coordinate rough-in locations of outlet boxes and conduits provided under Section provided under Section 26 05 33 as required for installation of raceways provided under this section.
 - 3. Verify minimum sizes of raceways with the actual conductors and components to be installed.
 - 4. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not install raceways until final surface finishes and painting are complete.
2. Do not begin installation of conductors and cables until installation of raceways is complete between outlet, junction and splicing points.

1.05. SUBMITTALS

- A. See Section 01 33 00 - Submittals, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets including dimensions, knockout sizes and locations, materials, fabrication details, finishes, service condition requirements, and accessories.

1.06. QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

PART 2 - PRODUCTS

2.01. RACEWAY REQUIREMENTS

- A. Provide all components, fittings, supports, and accessories required for a complete raceway system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Do not use raceways for applications other than as permitted by NFPA 70 and product listing.

PART 3 - EXECUTION

3.01. EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes and conduit terminations are installed in proper locations and are properly sized in accordance with NFPA 70 to accommodate raceways.

- C. Verify that mounting surfaces are ready to receive raceways and that final surface finishes are complete, including painting.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.02. INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install raceways plumb and level.
- D. Secure and support raceways in accordance with Section 260529 at intervals complying with NFPA 70 and manufacturer's requirements.
- E. Close unused raceway openings.
- F. Provide grounding and bonding in accordance with Section 260526.

3.03. FIELD QUALITY CONTROL

- A. Inspect raceways for damage and defects.
- B. Correct wiring deficiencies and replace damaged or defective raceways.

3.04. CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.05. PROTECTION

- A. Protect installed raceways from subsequent construction operations.

END OF SECTION

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SECTION 26 05 29

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Electrical identification requirements.
- B. Identification nameplates and labels.
- C. Wire and cable markers.
- D. Underground warning tape.
- E. Warning signs and labels.

1.02. RELATED REQUIREMENTS

- A. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables: Color coding for power conductors and cables 600 V and less; vinyl color coding electrical tape.

1.03. REFERENCE STANDARDS

- A. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- B. NFPA 70E - Standard for Electrical Safety in the Workplace; 2024.
- C. UL 969 - Marking and Labeling Systems; Current Edition, Including All Revisions.

1.04. ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Verify final designations for equipment, systems, and components to be identified prior to fabrication of identification products.
- B. Sequencing:
 - 1. Do not install identification products until final surface finishes and painting are complete.

1.05. SUBMITTALS

- A. Product Data: Provide manufacturer's standard catalog pages and data sheets for each product.

1.06. QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07. FIELD CONDITIONS

- A. Do not install adhesive products when ambient temperature is lower than recommended by manufacturer.

PART 2 - PRODUCTS

2.01. IDENTIFICATION REQUIREMENTS

- A. Identification for Equipment:

1. Use identification label to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
 - a. Panelboards:
 - (1) Identify power source and circuit number. Include location when not within sight of equipment.
 - (2) Use typewritten circuit directory to identify load(s) served for panelboards with a door. Identify spares and spaces using pencil.
 - (3) For power panelboards without a door, use identification nameplate to identify load(s) served for each branch device. Do not identify spares and spaces.
2. Available Fault Current Documentation: Use identification label to identify the available fault current and date calculations were performed at locations requiring documentation by NFPA 70 including but not limited to the following.
 - a. Service equipment.
 - b. Industrial control panels.

3. Arc Flash Hazard Warning Labels: Use warning labels to identify arc flash hazards for electrical equipment, such as switchboards, panelboards, industrial control panels, meter socket enclosures, and motor control centers that are likely to require examination, adjustment, servicing, or maintenance while energized.
 - a. Minimum Size: 3.5 by 5 inches (89 mm by 127 mm).
 - b. Legend: Include orange header that reads "WARNING", followed by the word message "Arc Flash and Shock Hazard; Appropriate PPE Required; Do not operate controls or open covers without appropriate personal protection equipment; Failure to comply may result in injury or death; Refer to NFPA 70E for minimum PPE requirements" or approved equivalent.
 - c. Service Equipment: Include the following information in accordance with NFPA 70.
 - (1) Nominal system voltage.
 - (2) Available fault current.
 - (3) Date label applied.

B. Identification for Conductors and Cables:

1. Color Coding for Power Conductors 600 V and Less: Comply with Section 26 05 19.
2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.
3. Use wire and cable markers to identify circuit number or other designation indicated for power, control, and instrumentation conductors and cables at the following locations:
 - a. Within equipment enclosures when conductors and cables enter or leave the enclosure.

2.02. IDENTIFICATION NAMEPLATES AND LABELS

A. Identification Nameplates:

1. Materials:
 - a. Outdoor Locations: Use plastic, stainless steel, or aluminum nameplates suitable for exterior use.
2. Plastic Nameplates: Two-layer or three-layer laminated acrylic or electrically non-conductive phenolic with beveled edges; minimum thickness of 1/16 inch (1.6 mm); engraved text.
3. Stainless Steel Nameplates: Minimum thickness of 1/32 inch (0.8 mm); engraved or laser-etched text.
4. Aluminum Nameplates: Anodized; minimum thickness of 1/32 inch (0.8 mm); engraved or laser-etched text.
5. Mounting Holes for Mechanical Fasteners: Two, centered on sides for sizes up to 1 inch (25 mm) high; Four, located at corners for larger sizes.

B. Identification Labels:

1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.

C. Format for Receptacle Identification:

1. Minimum Size: 3/8 inch (10 mm) by 1.5 inches (38 mm).
2. Legend: Power source and circuit number or other designation indicated.
3. Text: All capitalized unless otherwise indicated.
4. Minimum Text Height: 3/16 inch (5 mm).
5. Color: Black text on clear background.

2.03. WIRE AND CABLE MARKERS

- A. Markers for Conductors and Cables: Use wrap-around self-adhesive vinyl cloth, wrap-around self-adhesive vinyl self-laminating, heat-shrink sleeve, plastic sleeve, plastic clip-on, or vinyl split sleeve type markers suitable for the conductor or cable to be identified.
- B. Markers for Conductor and Cable Bundles: Use plastic marker tags secured by nylon cable ties.
- C. Legend: Power source and circuit number or other designation indicated.
- D. Text: Use factory pre-printed or machine-printed text, all capitalized unless otherwise indicated.
 - 1. Do not use handwritten text.
- E. Minimum Text Height: 1/8 inch (3 mm).
- F. Color: Black text on white background unless otherwise indicated.

2.04. UNDERGROUND WARNING TAPE

- A. Materials: Use non-detectable type polyethylene tape suitable for direct burial, unless otherwise indicated.
- B. Non-detectable Type Tape: 6 inches (152 mm) wide, with minimum thickness of 4 mil (0.1 mm).
- C. Legend: Type of service, continuously repeated over full length of tape.
- D. Color:
 - 1. Tape for Buried Power Lines: Black text on red background.

2.05. WARNING SIGNS AND LABELS

- A. Comply with ANSI Z535.2 or ANSI Z535.4 as applicable.
- B. Warning Signs:
 - 1. Materials:

- a. Indoor Dry, Clean Locations: Use factory pre-printed rigid plastic or self-adhesive vinyl signs.
 2. Minimum Size: 7 by 10 inches (178 by 254 mm) unless otherwise indicated.
- C. Warning Labels:
1. Materials: Use factory pre-printed or machine-printed self-adhesive polyester or self-adhesive vinyl labels; UV, chemical, water, heat, and abrasion resistant; produced using materials recognized to UL 969.
 2. Machine-Printed Labels: Use thermal transfer process printing machines and accessories recommended by label manufacturer.
 3. Minimum Size: 2 by 4 inches (51 mm by 102 mm) unless otherwise indicated.

PART 3 - EXECUTION

3.01. PREPARATION

- A. Clean surfaces to receive adhesive products according to manufacturer's instructions.

3.02. INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install identification products to be plainly visible for examination, adjustment, servicing, and maintenance. Unless otherwise indicated, locate products as follows:
 1. Surface-Mounted Equipment: Enclosure front.
 2. Flush-Mounted Equipment: Inside of equipment door.
 3. Free-Standing Equipment: Enclosure front; also enclosure rear for equipment with rear access.
 4. Elevated Equipment: Legible from the floor or working platform.
 5. Branch Devices: Adjacent to device.
 6. Interior Components: Legible from the point of access.

7. Conductors and Cables: Legible from the point of access.

- C. Install identification products centered, level, and parallel with lines of item being identified.
- D. Secure nameplates to exterior surfaces of enclosures using stainless steel screws and to interior surfaces using self-adhesive backing or epoxy cement.
- E. Install self-adhesive labels and markers to achieve maximum adhesion, with no bubbles or wrinkles and edges properly sealed.
- F. Install underground warning tape above buried lines with one tape per trench at 3 inches (75 mm) below finished grade.
- G. Mark all handwritten text, where permitted, to be neat and legible.

3.03. FIELD QUALITY CONTROL

- A. Replace self-adhesive labels and markers that exhibit bubbles, wrinkles, curling or other signs of improper adhesion.

END OF SECTION

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SECTION 26 08 50

FIELD ELECTRICAL ACCEPTANCE TESTS

PART 1 - GENERAL

1.01. REFERENCE STANDARDS

- A. NETA ATS - Standard for Acceptance Testing Specifications for Electrical Power Equipment And Systems; 2025.
- B. NFPA 70B - Recommended Practice for Electrical Equipment Maintenance; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- C. NFPA 70E - Standard for Electrical Safety in the Workplace; 2024.

1.02. SUMMARY

- A. This Section includes requirements for field electrical acceptance testing of electrical systems and equipment prior to energization and final acceptance.
- B. Acceptance testing shall verify that electrical installations comply with the Contract Documents, manufacturer's requirements, NEC, and applicable industry standards.
- C. Testing requirements apply to all electrical systems furnished and installed under Division 26.

1.03. REFERENCES

- A. National Electrical Code (NEC), latest adopted edition
- B. NETA ATS – Standard for Acceptance Testing Specifications
- C. NFPA 70B – Recommended Practice for Electrical Equipment Maintenance
- D. IEEE applicable testing standards
- E. NIST – National Institute of Standards and Technology
- F. Manufacturer's installation and testing requirements

1.04. DEFINITIONS

- A. Acceptance Testing: Field tests performed after installation and prior to final acceptance to verify operation, safety, and compliance.
- B. Testing Agency: Qualified firm or personnel performing acceptance testing.

1.05. SUBMITTALS

- A. Action Submittals:
 - 1. Acceptance test procedures and test plan
 - 2. Qualifications of testing personnel
- B. Informational Submittals:
 - 1. Field test reports and data
 - 2. Calibration certificates for test equipment
 - 3. Deficiency and corrective action reports
- C. Closeout Submittals:
 - 1. Final signed acceptance test reports
 - 2. Certification of compliance

1.06. QUALITY ASSURANCE

- A. Acceptance testing shall be performed by a qualified independent testing agency or by manufacturer-certified personnel, unless otherwise approved by the Engineer.
- B. Testing personnel shall be trained and experienced in testing the specific equipment being evaluated.
- C. Test equipment shall be calibrated within the last 12 months and traceable to NIST.

1.07. COORDINATION

- A. Coordinate testing activities with:
 - 1. Owner

2. Engineer
3. Electrical Contractor
4. Utility company (where applicable)

- B. Testing shall be coordinated to avoid damage to equipment and interruption of existing services.

1.08. SAFETY

- A. Perform all testing in accordance with NFPA 70E electrical safety requirements.
- B. Provide appropriate personal protective equipment (PPE) for all testing activities.

PART 2 - PRODUCTS

2.01. TEST EQUIPMENT

- A. Provide test instruments suitable for the required tests and rated for the voltage and current involved.
- B. Test equipment shall be in good condition and properly calibrated.

PART 3 - EXECUTION

3.01. GENERAL REQUIREMENTS

- A. Perform acceptance testing after installation is complete and prior to permanent energization, unless otherwise approved.
- B. Notify the Engineer a minimum of 5 working days prior to testing.
- C. Do not energize equipment until acceptance testing is complete and approved.

3.02. EQUIPMENT AND SYSTEMS TO BE TESTED

- A. Acceptance testing shall include, but is not limited to:
 1. Switchboards and panelboards
 2. Motor control centers (MCCs)

3. Transformers
4. Motors and motor starters
5. Variable frequency drives (VFDs)
6. Protective relays and trip units
7. Feeder and branch circuit conductors
8. Grounding and bonding systems

3.03. TESTING REQUIREMENTS

- A. Perform tests in accordance with NETA ATS unless modified by this Section.
- B. Minimum testing shall include:
 1. Visual and mechanical inspection
 2. Continuity and grounding verification
 3. Insulation resistance testing (Megger)
 4. Torque verification of electrical connections
 5. Phase rotation verification
 6. Functional and operational testing

3.04. FUNCTIONAL TESTING

- A. Verify proper operation of:
 1. Control circuits
 2. Interlocks
 3. Protective devices
 4. Indications, alarms, and metering
- B. Verify proper operation under normal and simulated fault conditions where safe and applicable.

3.05. DEFICIENCIES

- A. Document all deficiencies discovered during testing.
- B. Correct deficiencies and re-test affected equipment at no additional cost to the Owner.

3.06. TEST REPORTS

- A. Provide detailed test reports including:
 - 1. Equipment identification
 - 2. Test procedures used
 - 3. Test results and measured values
 - 4. Pass/fail determination
 - 5. Name and signature of testing personnel

3.07. FINAL ACCEPTANCE

- A. Electrical systems will be considered acceptable when:
 - 1. All required tests have been completed
 - 2. All deficiencies have been corrected
 - 3. Final test reports have been submitted and approved

3.08. CLOSEOUT

- A. Include acceptance test reports in the final project closeout documentation.
- B. Provide electronic copies in PDF format.

END OF SECTION

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SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Lighting and appliance panelboards.
- B. Overcurrent protective devices for panelboards.

1.02. RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Section 26 05 29 - Hangers and Supports for Electrical Systems.
- C. Section 26 05 53 - Identification for Electrical Systems: Identification of products and requirements.
- D. Section 26 43 00 - Surge Protective Devices.

1.03. REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service; 2013e, with Amendments (2022).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- C. NECA 407 - Standard for Installing and Maintaining Panelboards; 2025.
- D. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- E. NEMA PB 1 - Panelboards; 2011.
- F. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 1000V or Less; 2023.
- G. NETA ATS - Standard for Acceptance Testing Specifications for Electrical Power Equipment And Systems; 2025.

- H. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations; Current Edition, Including All Revisions.
- J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations; Current Edition, Including All Revisions.
- K. UL 67 - Panelboards; Current Edition, Including All Revisions.
- L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures; Current Edition, Including All Revisions.
- M. UL 943 - Ground-Fault Circuit-Interrupters; Current Edition, Including All Revisions.

1.04. ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 4. Notify Engineer of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05. SUBMITTALS

- A. See Section 01 33 00 - Submittals, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
- C. Operation and Maintenance Manual

1.06. QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07. DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping and provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

PART 2 - PRODUCTS

2.01. MANUFACTURERS

- A. Source Limitations: Provide panelboards and associated components produced by single manufacturer and obtained from a single supplier.

2.02. PANELBOARDS - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 6,600 feet (2,000 m).
 - 2. Ambient Temperature:
 - a. Panelboards Containing Circuit Breakers: Between 23 degrees F (-5 degrees C) and 104 degrees F (40 degrees C).
- C. Short Circuit Current Rating:
 - 1. Provide panelboards with listed short circuit current rating not less than the available fault current at the installed location as indicated on the drawings.

- D. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.
- E. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- F. Bussing: Sized in accordance with UL 67 temperature rise requirements.
 - 1. Provide solidly bonded equipment ground bus in each panelboard, with a suitable lug for each feeder and branch circuit equipment grounding conductor.
- G. Conductor Terminations: Suitable for use with the conductors to be installed.
- H. Enclosures: Comply with NEMA EN 10250, and list and label as complying with UL 50 and UL 50E.
 - 1. Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - a. Outdoor Locations: Type 4X, stainless steel.
 - 2. Boxes: Galvanized steel unless otherwise indicated.
 - a. Provide wiring gutters sized to accommodate the conductors to be installed.
 - 3. Lockable Doors: All locks keyed alike unless otherwise indicated.
- I. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- J. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 26 43 00, list and label panelboards as a complete assembly including surge protective device.

2.03. LIGHTING AND APPLIANCE PANELBOARDS

- A. Description: Panelboards complying with NEMA PB 1, lighting and appliance branch circuit type, circuit breaker type, and listed and labeled as complying with UL 67; ratings, configurations and features as indicated on the drawings.
- B. Conductor Terminations:

1. Main and Neutral Lug Material: Copper, suitable for terminating copper conductors only.
 2. Main and Neutral Lug Type: Mechanical.
- C. Bussing:
1. Phase Bus Connections: Arranged for sequential phasing of overcurrent protective devices.
 2. Phase and Neutral Bus Material: Copper.
 3. Ground Bus Material: Copper.
- D. Circuit Breakers: Thermal magnetic bolt-on or plug-in type unless otherwise indicated.
- E. Enclosures:
1. Provide surface-mounted enclosures as indicated.
 2. Provide clear plastic circuit directory holder mounted on inside of door.
- 2.04. OVERCURRENT PROTECTIVE DEVICES
- A. Molded Case Circuit Breakers:
1. Description: Quick-make, quick-break, over center toggle, trip-free, trip-indicating circuit breakers listed and labeled as complying with UL 489, and complying with FS W-C-375 where applicable; ratings, configurations, and features as indicated on the drawings.
 2. Interrupting Capacity:
 - a. Provide circuit breakers with interrupting capacity as required to provide the short circuit current rating indicated, but not less than:

(1) 10,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
 3. Conductor Terminations:

- a. Lug Material: Aluminum, suitable for terminating aluminum or copper conductors.
- 4. Thermal Magnetic Circuit Breakers: For each pole, furnish thermal inverse time tripping element for overload protection and magnetic instantaneous tripping element for short circuit protection.
- 5. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
- 6. Provide the following circuit breaker types where indicated:
 - a. Ground Fault Circuit Interrupter (GFCI) Circuit Breakers: Listed as complying with UL 943, class A for protection of personnel.

2.05. SOURCE QUALITY CONTROL

- A. Factory test panelboards according to NEMA PB 1.

PART 3 - EXECUTION

3.01. EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the ratings and configurations of the panelboards and associated components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive panelboards.
- D. Verify that conditions are satisfactory for installation prior to starting work.

3.02. INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Install panelboards in accordance with NECA 407 and NEMA PB 1.1.
- D. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.

- E. Provide required support and attachment in accordance with Section 260529.
- F. Install panelboards plumb.
- G. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches (2000 mm) above the floor or working platform.
- H. Provide grounding and bonding in accordance with Section 26 05 26.
- I. Install all field-installed branch devices, components, and accessories.
- J. Provide filler plates to cover unused spaces in panelboards.

3.03. FIELD QUALITY CONTROL

- A. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers. Tests listed as optional are not required.
- B. Test GFCI circuit breakers to verify proper operation.
- C. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.04. ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.

3.05. CLEANING

- A. Clean dirt and debris from panelboard enclosures and components according to manufacturer's instructions.
- B. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

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SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Receptacles.
- B. Wall plates and covers.

1.02. RELATED REQUIREMENTS

- A. Section 26 05 19 - Low-Voltage Electrical Power Conductors and Cables: Manufactured wiring systems for use with access floor boxes with compatible pre-wired connectors.
- B. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- C. Section 26 05 34 - Surface Raceways for Electrical Systems: Surface raceway systems, including multioutlet assemblies.
- D. Section 26 05 53 - Identification for Electrical Systems: Identification of products and requirements.

1.03. REFERENCE STANDARDS

- A. FS W-C-596 - Connector, Electrical, Power, General Specification for; 2014h (Validated 2022).
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- C. NECA 130 - Standard for Installing and Maintaining Wiring Devices; 2016.
- D. NEMA WD 1 - General Color Requirements for Wiring Devices; 1999 (Reaffirmed 2020).
- E. NEMA WD 6 - Wiring Devices - Dimensional Specifications; 2021.
- F. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. UL 498 - Attachment Plugs and Receptacles; Current Edition, Including All Revisions.

- H. UL 943 - Ground-Fault Circuit-Interrupters; Current Edition, Including All Revisions.

1.04. ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
3. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
4. Notify Engineer of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.05. SUBMITTALS

- A. See Section 01 33 00 - Submittals, for submittal procedures.
- B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.
- C. Operation and Maintenance Manual.

1.06. QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.07. DELIVERY, STORAGE, AND PROTECTION

- A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

PART 2 - PRODUCTS

2.01. WIRING DEVICES - GENERAL REQUIREMENTS

- A. Provide wiring devices suitable for intended use with ratings adequate for load served.
- B. Wiring Device Applications:
 - 1. Receptacles Installed Outdoors or in Damp or Wet Locations: Use weather-resistant GFCI receptacles with weatherproof covers.
- C. Wiring Device Finishes:
 - 1. Wiring Devices Installed in Wet or Damp Locations: Gray with weatherproof cover.

2.02. RECEPTACLES

- A. General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
 - 1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
 - 2. NEMA configurations specified are according to NEMA WD 6.
- B. Convenience Receptacles:
 - 1. Tamper Resistant and Weather Resistant Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type and as weather resistant type complying with UL 498 Supplement SD suitable for installation in damp or wet locations; single or duplex as indicated on the drawings.

2.03. WALL PLATES AND COVERS

- A. Weatherproof Receptacle Covers for Wet Locations: Gasketed, cast aluminum, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

PART 3 - EXECUTION

3.01. EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- F. Verify that conditions are satisfactory for installation prior to starting work.

3.02. INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Install wiring devices in accordance with manufacturer's instructions.
- C. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- D. Where required, connect wiring devices using pigtails not less than 6 inches (150 mm) long. Do not connect more than one conductor to wiring device terminals.
- E. Connect wiring devices by wrapping conductor clockwise 3/4 turn around screw terminal and tightening to proper torque specified by the manufacturer. Where present, do not use push-in pressure terminals that do not rely on screw-actuated binding.
- F. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- G. Install wiring devices plumb and level with mounting yoke held rigidly in place.

- H. Install vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.
- I. Install wall plates to fit completely flush to wall with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.

3.03. FIELD QUALITY CONTROL

- A. See Section 01 45 16 – Contractor Quality Control, for additional requirements.
- B. Inspect each wiring device for damage and defects.
- C. Test each receptacle to verify operation and proper polarity.
- D. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.04. ADJUSTING

- A. Adjust devices and wall plates to be flush and level.

3.05. CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION

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SECTION 26 28 11

LOW-VOLTAGE POWER CIRCUIT BREAKERS

PART 1 - GENERAL

1.01. ABBREVIATIONS AND ACRONYMS

- A. LVPCB: Low-voltage power circuit breakers.
- B. ERMS: Energy reduction maintenance setting.

1.02. DEFINITIONS

- A. Operator Interface Terminal (OIT): Locally mounted HMI device that provides remote monitoring and functions of connected equipment.

1.03. REFERENCE STANDARDS

- A. ISO 9001 - Quality Management Systems — Requirements; 2015, with Amendment (2024).
- B. ISO 14001 - Environmental Management Systems — Requirements with Guidance for Use; 2015.
- C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. UL 1066 - Low-Voltage AC and DC Power Circuit Breakers Used in Enclosures; Current Edition, Including All Revisions.

1.04. SUBMITTALS

- A. See Section 01 33 00 for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for circuit breakers, enclosures, and other installed components and accessories.
- C. Operation and Maintenance Data:

1. Provide detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.

1.05. QUALITY ASSURANCE

A. Comply with the following:

1. NFPA 70.
2. Requirements of local authorities having jurisdiction.
3. Applicable local codes.

B. Manufacturer Qualifications:

1. Firm engaged in manufacture of specified products of types and sizes required, and whose products have been in satisfactory use in similar service for minimum of 10 years.
2. Certified in accordance with ISO 9001 with applicable quality assurance system regularly reviewed and audited by third-party registrar. Develop and control manufacturing, inspection, and testing procedures under guidelines of quality assurance system.
3. Service, repair, and technical support services available 24 hours per day, 7 days per week from manufacturer or their representative.
4. Certified in accordance with ISO 14001, with product environmental profiles (PEPs) for specified products.

1.06. DELIVERY, STORAGE, AND HANDLING

- A. Prior to delivery to project site, verify suitable storage space is available to store materials in well-ventilated area protected from weather, moisture, soiling, extreme temperatures, humidity, and corrosive atmospheres.
- B. Protect materials during delivery and storage and maintain within manufacturer's written storage requirements. At minimum, store indoors in clean, dry space with uniform temperature to prevent condensation and protect electronics from potential damage from electrical and magnetic energy.

- C. Deliver materials to project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and equipment tag number or service name as identified in Contract Documents.
- D. Inspect products and report concealed damage or violation of delivery, storage, and handling requirements to Engineer.

1.07. FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.08. WARRANTY

- A. Manufacturer Warranty: Provide manufacturer warranty for defects in material and workmanship for 12 months from date of commissioning or 18 months from date of shipment, whichever comes first. Complete forms in Owner's name and register with manufacturer.

PART 2 - PRODUCTS

2.01. MANUFACTURERS

- A. Schneider Electric; Square D MasterPacT Low-Voltage Power Circuit Breakers; www.se.com/#sle.
- B. Source Limitations: Furnish products produced by same manufacturer as other electrical distribution equipment for project and obtained from single supplier.

2.02. LOW-VOLTAGE POWER CIRCUIT BREAKERS

- A. Basis of Design: Schneider Electric; Square D MasterPacT Low-Voltage Power Circuit Breakers; www.se.com/#sle.
- B. Listed as complying with UL 1066.
- C. Provide sealed low-voltage power circuit breaker (LVPCB), manually operated, with integrally mounted electronic trip units.
- D. Provide fixed mounted circuit breakers.

- E. Circuit Breaker Rating: 100 percent rated.
- F. Interrupting Rating: Available up to 130 kAIR RMS at 635 V, 200 kAIR RMS at 508 V, and 200 kAIR RMS at 254 V without fuses.
- G. Thirty-Cycle Withstand Ratings: Comply with application requirements.
- H. Close-and-Latch Rating: Up to 150 kA peak current.
- I. Maximum Closing Time:
 - 1. Provide maximum 5-cycle closing time.
 - 2. Ratings Less than 800 A: 50 milliseconds.
 - 3. Ratings Between 800 A and 4,000 A: 70 milliseconds.
 - 4. Ratings Greater than 4,000 A: 80 milliseconds.
- J. Service Life:
 - 1. Frame Size of 3,200 A or Less: Certified for 10,000 operations without maintenance.
 - 2. Frame Size Greater than 3,200 A: Certified for 5,000 operations without maintenance.
 - 3. Provide visual contact wear indicator.
- K. Operation:
 - 1. Provide two-step, fully-stored energy devices for quick-make, quick-break operation.
 - a. Capable of open-close-open cycle without recharging.
 - b. Automatically charge motor operator when breaker is closed.
 - c. Step One: Actuation of operating handle or operation cycle of circuit breaker motor charges closing springs.
 - d. Step Two: Operation of local close button closes circuit breaker contact, automatically charging opening springs.

2. Anti-Pumping Function: Remains in open position if opening/closing commands occur simultaneously; after fault tripping or intentional opening using manual or electrical controls, requires closing order to be discontinued and reactivated.
3. Provide OPEN and CLOSE buttons with lockable clear cover.
4. Provide breaker contact and close spring status indicators; indicate "charged-not OK to close" if closing springs are charged but circuit breaker is not ready to close.
5. Locking Provisions: For locking in connected, test, or disconnected position.
 - a. Pad-Lock Provisions: One to three.
 - b. Key-Lock Provisions: One to two.
6. Support auxiliary status contacts for open/close (ON/OFF), tripped, ready to close, ready to open, and spring mechanism is charged to provide local or remote indications of proper breaker system functionality.
7. Provide safety interlock to keep circuit breaker open if trip unit is not installed.
8. Shunt Trip and Shunt Close Coils: Continuous-duty rated; intermittent duty rated coils dependent on coil clearing contact may be used where spare coil is provided for each breaker.

L. Construction:

1. Case: Polyester thermoset material with high dielectric strength.
2. Current-Carrying Components: Isolated from accessory mounting area and double-insulated from operator with accessory cover in place.
3. Isolate each phase and ground.
4. Equipped with metal filters to reduce effects of interruption on surfaces surrounding circuit breaker.
5. Secondary Wiring: Front accessible with cage clamp connections.
6. Comply with Registration Evaluation and Authorization and Restriction of Chemicals (REACH) and Restriction of Hazardous Substances (RoHS).

M. Electronic Trip Units:

1. Digital Modules:
 - a. Provide capability to upgrade trip unit functions by uploading digital modules without requiring replacement/modification of hardware.
 - b. Electronically manage trip unit protection functions independently of measurement functions by dedicated application-specific integrated circuit (ASIC).
 - c. Support uploading of digital modules to trip unit without removing power from circuit breaker.
2. Provide local and remote trip indication with cause of trip (e.g., overload, short circuit, or ground fault).
3. Visually indicate circuit breaker operating status (normal, warnings, alarms, energy reduction maintenance setting) via color-changing backlit display.
4. Provide capability to set breaker locally, via smart mobile device, or remotely through communications.
5. Provide sealable door to block use of local display for deterrence of unwanted protection setting changes.
6. Support extraction of trip cause data from trip unit and adjustment of protection settings without 24 VDC power supply or when main circuit breaker is OFF using portable power supply connected through USB port, including battery pack, smart mobile device (USB OTG), or laptop PC.
7. Provide true RMS sensing through 40th harmonic; indicate long-time pickup with LEDs.
8. Coils: Provide status, self-diagnostics (functionality and number of coil operations), and wiring diagnostics. Coils without these features to be provided with separate system to communicate status/alarms to remote monitoring system.
9. Where indicated on drawings, provide electronic trip units with the following field-adjustable protection settings:

- a. Long-Time (ANSI 49RMS/51):
 - (1) Pickup: Adjustable from 40 to 100 percent of nominal current rating in 1 A increments; where 1 A increments are not possible, provide complete set of rating plugs for each breaker.
 - (2) Delay: Adjustable from 0.5 to 24 seconds at 600 percent of long-time pickup in 0.5-second increments.
 - b. Instantaneous (ANSI 50):
 - (1) Pickup: Adjustable from 150 percent to 1,500 percent of nominal current rating.
 - (2) Selectable Breaking Times:
 - (a) Standard: For selective coordination.
 - (b) Fast: For limiting let-thru energy; between 25 and 30 milliseconds.
10. Provide dual trip curve settings for each protection function (LSIG) with separate settings for utility, generator set, or grid sources; selectable by digital input through I/O module, Ethernet, or local display.
11. Energy Reduction Maintenance Setting (ERMS):
- a. Trip Unit: Provide separate trip curve for arc energy reduction maintenance setting selected via physical selector switch or smart mobile device; operate in fast instantaneous trip mode (25 to 30 milliseconds), when trip curve is active.
 - b. Provide remote indicator light to indicate trip unit is in ERMS mode.
12. Measurement and Analysis Functions:
- a. Provide trip unit embedded measurement for real-time metering. Where trip unit embedded measurement is not available, provide external meter.
 - b. Metering Accuracy:
 - (1) Current and Voltage: 0.5 percent.

- (2) Power and Energy: 1 percent.
 - (3) Specified accuracies are for total measurement system, including CT and meter.
 - (4) Full scale over range of 10 to 120 percent of long-time pickup.
- c. Energy Measurement:
 - (1) Imported and exported energy on each phase of power system network.
 - (2) Active, reactive, and apparent energy, per phase and total.
- d. Harmonic Analysis and Waveform Capture: Individual harmonics of voltages and currents up to 40th harmonic, calculated every 200 milliseconds in accordance with IEC 61000-4-30.
- e. Support display of measurements on breaker HMI display, smart mobile device via Bluetooth, connected remote operator interface terminal, or remote monitoring system via Modbus TCP/IP.
- f. Event Management:
 - (1) Provide event management to assist in compliance with NFPA 70B.
 - (2) Provide notification of alarms and traceability, including event history of trips, protection setting changes, diagnostics, metering, configuration, and operation.
 - (3) Record date and time entry was made and user ID associated with change.
 - (4) Support alarm activation based on measurement or counters.
 - (5) Support availability of events by communication via Bluetooth and Modbus TCP/IP or by software engineering tool.
- g. Internal Monitored Functions:
 - (1) Circuit Breaker: Coil electrical continuity checks, circuit breaker closing time, gear motor charging time, circuit breaker closing and

opening counter, circuit breaker time stamp closing and opening history log.

- (2) Trip Unit: Internal sensor continuity (CTs), external sensor disconnection (ENCT, ground-fault sensor, I/O modules), internal failure discrimination (ASIC, sensor plugs, internal battery, trip solenoid), wireless communication failure (Bluetooth low energy, Ethernet).

13. Smart Mobile Device App:

- a. Communicate trip cause information to smart mobile device without requiring power to trip unit.
- b. Provide virtual assistance in reclosing breaker after trip event utilizing information extracted from breaker, including waveform capture on trip event.
- c. Display circuit breaker event information, potential trip causes, list of additional investigations needed to determine if power can be restored, and recommendations for power restoration.

14. Auto-Test Function: Monitor and communicate trip unit state, battery state, contact state, circuit breaker remaining life estimate (algorithm based), opening/closing function, and spring charging function; indicate by health state LED, embedded HMI display, and smart mobile device app.

15. Support remote open/close operation via wired communication or smart mobile device that delivers instructions based on ready-to-close, coil, and spring charging status.

16. Communications:

- a. Provide USB communication/test port to check electronic and trip mechanism operation without requiring manufacturer's special hardware tool.
- b. Provide wireless communication interface for protection settings and health checks using near field communications (NFC) and Bluetooth low energy (BLE) protocols.

- c. Provide communication interface with two Modbus TCP/IP 10/100 Mbps ports (dual-port, single network) for connection to Ethernet network for real-time access to data and settings.
- d. Provide embedded web page interface accessed via standard PC and web browser without requiring additional hardware or software.
- e. Comply with Device Profile for Web Services (DPWS) for auto-discovery on local area network (LAN).
- f. Capable of reporting drawout circuit breaker cradle position, viewable in embedded web page and over data connection to external monitoring software.
- g. Trip unit and communication accessories for all Ethernet network accessible LV circuit breakers shall comply with cyber security global standards such as ISA/IEC 62443-4-1, ISA/IEC 62443-4-2, US cyber security regulations SB327, HB2395, NFPA 70 (NEC) 240.6 (D), UL 5500, DODI 8510.01, US data privacy regulations, and shall be part of a certified ISA/IEC 62443-3-3 reference architecture.

PART 3 - EXECUTION

3.01. INSTALLATION

- A. Install circuit breakers in accordance with manufacturer's written instructions.

3.02. FIELD QUALITY CONTROL

- A. Manufacturer Services: Provide services of manufacturer's field representative to perform functional testing, commissioning, and first parameter adjusting.
 - 1. Include necessary material, equipment, labor, and technical supervision.
 - 2. Replace damaged or malfunctioning equipment and report discrepancies or installation issues.

END OF SECTION

SECTION 26 42 13

CATHODIC PROTECTION

PART 1 - GENERAL

1.01. SUMMARY

- A. Work under this section is subject to all the requirements of the Contract Documents, including the General Conditions, Special Conditions and all the related sections of the Specifications.
- B. Related Work Specified Elsewhere:
 - 1. Painting and Coating: Section 09 90 00
 - 2. Utility Identification: 33 05 26
 - 3. Welded Steel Transmission Pipe: Section 33 11 11

1.02. SCOPE OF WORK

- A. The corrosion control shall consist of monitoring and impressed current cathodic protection (CP) systems which shall include the furnishing and installation of all wiring, test stations, anodes, AC power, exothermic welding, coating repairs, joint bonding, and all other work and items required for a complete and functioning system for the specified buried piping, metallic fittings, and other appurtenances.
- B. The CP systems shall be installed as shown on the Drawings and as specified herein.
- C. The installation and testing of each CP system shall be overseen by a National Association of Corrosion Engineers (NACE) certified Cathodic Protection Specialist (CP4) engaged by the Contractor. Approval of the NACE CP Specialist (CP4) shall be subject to the approval of Owner or Designated Representative.

1.03. REFERENCES

- A. The CP system installations shall comply with applicable requirement codes, laws and ordinances of Federal, State and Local bodies having jurisdiction; the National Association of Corrosion Engineers (NACE), including applicable supplements, bulletins and special rulings.
- B. Where more stringent requirements than code are shown or specified, the more stringent requirements shall apply. All electrical items shall be UL listed or labeled, where such listing or labeling is obtainable.

C. Applicable Standards:

1. National Association of Corrosion Engineers (NACE):
 - a. Standard Practice SP0169 – Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
 - b. Standard Practice SP0286 – Electrical Isolation of Cathodically Protected Pipelines.
 - c. Standard Practice SP572 – Design, Installation, Operation, and Maintenance of Impressed Current Deep Groundbed.
2. National Electrical Code (NEC).
3. Underwriters Laboratory (UL).

1.04. RELATED WORK SPECIFIED ELSEWHERE

- A. Dielectric couplings, protective pipe coating, wrapping, and patching will be provided by the Contractor under other sections of the specifications.
- B. Backfilling other than specified herein for anodes will be provided by the Contractor under another section of the specifications.

1.05. DEFINITIONS

- A. Active Column of Anode Groundbed: The portion of the groundbed that discharges current; consists of anodes and coke breeze.
- B. Anode Groundbed:
 1. Cathodic protection anode(s) that is installed in a drilled or excavated hole at a prescribed depth from the structure being cathodically protected to achieve electrical remoteness.
 2. Typically, anodes and coke breeze are installed in the lower portion (active column) and high resistant or sealing material is installed in the top section of the drilled hole (inactive column).
- C. Cathodic Protection: The electrical method of reducing or eliminating corrosion by making previous anodic areas on the structure surface a cathode by creating a DC current flow to the structure by use of a cathodic protection system.
- D. Cathodic Protection Criteria: Conform to NACE SP0169.
- E. Cathodic Protection Systems:

1. Galvanic anode system: Galvanic anode material, usually magnesium or zinc, which naturally corrodes or sacrifices itself and does not require an outside power source.
 2. Impressed current system: Utilizes an outside power source, usually a rectifier (that converts AC to DC current), and forces (impresses) current from a number of anodes (or ground bed) through the environment to the structure to be protected.
- F. Cathodic Protection Station (CPS): An impressed current cathodic protection installation location consisting of rectifier, groundbed, and anode terminal box.
- G. Electrically Continuous Pipeline: Linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this Section.
- H. Electrical Isolation: The condition of being electrically isolated from other metallic structures and the environment as defined in NACE RP0286.
- I. Ferrous or Metallic Pipe: Pipe or structure made of steel or iron alloys and pipe or structure containing steel or iron as a principal structural material (such as steel, ductile iron, and cast iron).
- J. Foreign-Owned: Buried pipe or cable not specifically owned or operated by the Owner or Designated Representative.
- K. Functional and Performance Testing:
1. Testing that is necessary to demonstrate that the installed equipment and systems function as specified and operate in the manner intended.
 2. Functional testing is a prerequisite to performance testing for equipment and systems that are specified to have a performance test.
- L. Inactive Column of Groundbed: The portion of groundbed which does not discharge current; consists of the gravel fill, casing, and/or bentonite seal which is above the active column.
- M. Lead, Lead Wires, Joint Bond, and Cable: Insulated copper conductor; the same as wire.
- N. Manufacturer's Representative: An employee of the manufacturer who is factory trained and knowledgeable in the technical aspects of their products and systems.
- O. Raceways: Conduit, plastic or metal pipe, or electrical metallic conduit (EMT) for the casing of electrical or cathodic protection cables.

- P. Structure-to-Reference Electrode Potential (also Structure-to-Reference Electrode Voltage): The difference in voltage (potential) between the subject metallic structure and the electrolyte in which it is buried or submerged, as measured to the standard specified reference electrode placed in contact with the electrolyte.

1.06. PERFORMACE REQUIREMENTS

- A. Show evidence of UL approval were UL standards exist and product listings are available.
- B. Conform to National Electrical Code (NEC) and applicable federal, state, and local laws, codes, and regulations.
- C. When requirements of specification or drawings exceed those of codes or the manufacturer's instruction, requirements of Specifications or Drawings prevail.

1.07. SUBMITTALS

- A. Products and Manufacturers:
 - 1. As soon as practicable and within thirty (30) days after the date of receipt of notice to proceed, and before any material or equipment is purchased, the Contractor shall submit for approval a complete list of materials and equipment to be incorporated in the work. The list shall include catalog numbers, cuts, diagrams, drawings and other descriptive data as may be necessary. No consideration will be given to partial lists submitted from time to time. Approval will be based on the manufacturer's published ratings. Any materials and equipment listed, which are not in accordance with the specification requirements, will be rejected. Include manufacturer's name and provide sufficient information to show that materials meet the requirements of the project.
 - 2. As a minimum, submittals for the following items are required:
 - a. Galvanic and impressed current anode alloy, size, and wire type and length.
 - b. Coke breeze and inactive column backfill materials.
 - c. Vent piping and casings.
 - d. Rectifier control units.
 - e. Remote monitoring units.
 - f. Dielectric insulating fittings.

- g. Test station and junction box enclosures, terminal boards, and shunts.
 - h. Test station wire conductors.
 - i. Reference electrodes and coupons.
 - j. Joint bond wire.
 - k. Exothermic welding equipment.
 - l. Exothermic weld connection coating systems.
 - m. Wire splice kits.
 - n. Wire marker tags and labels.
 - o. Wire terminals.
 - p. Enclosures for impressed current rectifiers, junction boxes, and other components.
- B. As soon as practicable and within thirty (30) days after the date of receipt of notice to proceed, and before any material or equipment is purchased, the Contractor shall submit for approval:
- 1. Qualifications and certification of the Contractor's NACE CP Specialist (CP4).
 - 2. The CP Test Plan as prepared by the Contractor's NACE CP Specialist (CP4).
- C. After completion of the CP installation work, and in compliance with the data submittal requirements of the contract documents, the Contractor shall submit the following:
- 1. Record drawings of installation and construction of CPS; accurate location and type of anodes, wires, conduits, insulators, pipe connections, and junction boxes.
 - 2. Anode groundbed as-built information including, but not limited to:
 - a. Drilling / excavation log.
 - b. Soil resistance testing log.
 - c. Backfilled anode resistance log test results.
 - d. Final anode placement, coke breeze, casing, and seal depths.
 - 3. Field test reports.

4. Cathodic protection system test report and O&M manual.

1.08. QUALITY CONTROL

A. Contractor's CP Specialist (CP4) Qualifications:

1. Currently certified by NACE as a CP Specialist (CP4).
2. Shall have successfully completed a minimum of ten Contracts of similar nature and scope as that indicated in this Specification.
3. Oversee or perform all installation and testing services during installation of CP system components associated with the project.
4. Visit the site for testing and specification compliance verification a minimum of once every two weeks or more frequent as needed.
5. Ensure the proper installation of the galvanic and impressed current cathodic protection systems indicated on the Contract Drawings, verify electrical continuity of the pipeline, verify the effectiveness of insulating fittings, and obtain test results of the CP system.

B. The Contractor's NACE CP Specialist (CP4) shall prepare a written test program and shall perform or supervise all testing as the work progresses and for the completed work. The testing program shall include:

1. Procedures for verifying electrical continuity of pipe joints provided with continuity bond cables after construction.
2. Procedures for measuring the CP potentials and anode currents for the structure.
3. Methods for determining the effectiveness of dielectric fittings.

C. Manufacturer's Qualifications:

1. Regularly engaged on a full-time basis in the manufacture of products in this Section for a minimum of 5 years.
2. Provide certification that all materials and components meet the requirement of the Drawings and Specifications and applicable standard details.

D. Field Supervision:

1. Provide s Superintendent or Foreman to supervise the construction site.
2. Minimum of 2 years of experience in cathodic protection.

1.09. DELIVERY, STORAGE, AND HANDLING

A. Cathodic Protection Materials:

1. Store off the ground.
2. Protect against weather, condensation, and mechanical damage.
3. Handle with care.
4. Do not sharply bend or tightly coil the wire.
5. Replace equipment or materials damaged in shipment or installation.

B. Anodes:

1. Coil the anode wires and secure and package the anode in crates as required to prevent damage during shipping.
2. Ensure that the wire is not damaged and that the anodes or lead connection at the anode end are not physically stressed.
3. If anode or wires are damaged, replace the complete anode.

C. Coke Breeze:

1. Bulk or bag shipping.
2. Shipped and stored in a manner to keep it dry in order to minimize it from freezing solid.
3. If bagged, provide and ship in waterproof bags.
4. Bags shall be UV resistant or protected with tarps to protect from UV exposure.

D. Reference electrodes:

1. Do not allow to freeze.
2. Store in a protected area.
3. Utilize before shelf life expires.

PART 2 - PRODUCTS

2.01. STANDARD PRODUCTS

- A. Materials and equipment submitted for approval under this specification shall be product of a manufacturer regularly engaged in the manufacture of the product, shall be of the best quality used for the purpose in commercial service, shall be the respective manufacturers latest standard design and shall meet the requirements of the specifications.
- B. Materials and equipment shall be new and the manufacturer's latest standard design that complies with the specification requirements conforming to NACE Standards.
- C. Use of the manufacturer's name and model or catalog number is for the purpose of establishing a standard quality and the general configuration desired.
- D. Substitutions: As approved by Owner or Designated Representative if considered equal.
- E. Exposed assemblies that are visible to public, including cabinets, supports, conduits and pipes shall be galvanized and painted per City of Thornton Mocha Brown Color or as indicated otherwise.

2.02. MATERIALS AND EQUIPMENT

- A. Manual Controlled Rectifier:
 - 1. Sources: Advantage Air Cooled Line by Integrated Rectifier Technologies.
 - 2. Mount a permanent means of identification such as an engraved name plate on the interior of the door:
 - a. List the manufacturer's name and phone number, model number, year manufactured, serial number, and AC and DC electrical input and output electrical outlet ratings.
 - 3. Meet the requirements of NEMA 3x, cathodic protection rectifier units.
 - a. Air-cooled.
 - b. Manually controlled.
 - c. Designed to operate continuously at the full rated output at an ambient temperature of -58°F to 113°F.

- d. Single phase, bridge type with silicon diode or selenium stack, capable of operation at 110% of the rated input/output without damage to the components.

Location / ID	Volts	Amps
Segment F.1	40	35

4. Provide:

- a. Hybrid bridge stack or mercury relay for future installation of remote monitoring unit.
- b. Terminal block mounted on front panel for future installation of remote monitoring unit. Include DC volt +/-, DC Amps +/-, 12VDC Interruption, and 115 VAC +/-.
- c. Dual AC input of 120/240 volts, single phase, 60Hz and a suitably sized magnetic type circuit breaker on the front of the panel.
- d. Suitably sized heat sinks to maintain the rectifying element and the case temperatures below the maximum temperature recommended by the manufacturer.
- e. Selenium surge plates and current and voltage limiting devices.
- f. Lighting protection devices (surge arrestors) on both AC input and DC output.
- g. Fine and course secondary taps with output controlled by a minimum of 30 evenly divided transformer tap settings; arrange in consecutive order.
- h. 120-volt convenience outlet.
- i. Proper sized pedestal or bracket for mounting.

5. Rectifier transformer:

- a. Separate and secondary type.
- b. Minimum efficiency: 94%.
- c. Meet the requirements of NEMA and UL.
- d. Transformer insulation: Rated for a minimum 130°C with the actual hottest spot temperature at the rated conditions not to exceed 100°C.

6. Meters:
 - a. Separate voltage and current meters.
 - b. D'Varsonal movement type.
 - c. Accurate to within 2% of actual voltage and current output.
 - d. Tested and calibrated at the factory.
 - e. Test in the field for accuracy.
 - f. Have inaccurate meters replaced by the manufacturer.
 - g. Able to measure the rectifier output plus 25%.
7. Shunts:
 - a. External panel mounted.
 - b. Holloway type or approved equal.
 - c. In series with ammeter.
 - d. Clearly identify shunt voltage and amperage.
8. Rectifier panel board:
 - a. Mount rectifier meters, shunt, AC circuit breaker, taps, AC and DC fuses, and DC output terminals.
 - b. Non-metallic.
 - c. Construct of sufficient thickness to withstand shipping and operational stresses.
 - d. Locate at the front of the rectifier to allow access for testing and adjustment.
9. Rectifier DC terminals:
 - a. Solderless lug type of the appropriate size to accommodate the specified size cables on this project.
 - b. Tap studs, tap bars, nuts, and washers: Suitably sized brass, bronze, nickel, or tin-plated copper.

- c. Clearly engrave or identify the polarity of the rectifier DC terminals, fine and course transformer tap numbering, meters, and fuses with a permanent marking system on the rectifier panel; stick on labels or tape are not acceptable.
- 10. Provide an enclosure for the transformer, AC circuit breaker, rectifier stacks, lighting arrestors, DC output meters, and wiring connections:
 - a. Material: Minimum 16-gauge steel.
 - b. Finish: Hot-dipped galvanized or baked enamel; color to be selected.
 - c. Air-cooled.
 - d. Meet the requirements of NEMA 3R.
 - e. Suitable ventilation for adequate cooling of the rectifier by natural air convection.
 - f. Protect interior components from weather, vandalism, and nest building insects.
- 11. Provide:
 - a. A grounding lug on the outside of the cabinet.
 - b. Hinged and removable doors on the front and on both sides to allow access.
 - c. Stainless steel latches and a hasp for padlocking.
 - (1) For air cooled standard type rectifiers up to 25 ampere DC output, provide one size larger case size than is standard for the rectifier rating to aid in cooling and access for testing and maintenance.
 - (2) For 26 ampere DC output size rectifiers or larger, provide with a standard size case.
- 12. Provide spare parts:
 - a. Two complete sets of fuses.
 - b. Two of each type of diode.
 - c. Two AC input lightning arrestors.
 - d. Two DC output lightning arrestors.

13. AC Power Service: To be provided by Contractor at all locations.
 - a. 120 volt or 240 volt circuit with a dedicated negative/ground circuit. 240 volt circuit is preferred for rectifier efficiency.
 - b. Single phase, 60 hertz.
 - c. Include an AC disconnect panel with a minimum 20-amp breaker or fuse.

B. Remote Monitoring Unit:

1. Sources: Watchdog Scout by Elecsys (no substitutions allowed)
2. Satellite or cellular configuration with four (4) circuits to measure rectifier volts, rectifier amps, structure-to-electrolyte 'on' potential, and structure- to-electrolyte 'off' potential.
 - a. Confirm anticipated telemetry of location with manufacturer and provide a satellite or cellular unit as required.
 - b. Include:
 - (1) 100-amp mercury relay
 - (2) AC step-down transformer
 - c. Remote monitor shall be able to synchronize with other remote units.

C. Impressed Current Anodes

1. Description: High silicon, chromium iron centrifugally or chill cast in tubular form.
2. Material: High silicon, chromium iron alloy, manufactured in accordance with ASTM A 518/A 518M, Grade 3 with chemical composition percentages as follows:

Element	Composition, Weight %
Carbon	0.70 – 1.10
Manganese	1.50 Maximum
Silicon	14.20 – 14.75
Chromium	3.25 – 5.00
Molybdenum	0.20 Maximum
Copper	0.50 Maximum

3. Centrifugally and chill cast anodes:

- a. In tubular form with hollow, straight walled design.
- b. Do not exceed 1/4 bowing and malformation tolerances over the length of the anode.
- c. Solid walls of uniform thickness with and open cylindrical interior.

4. Size of the anodes:

Type	Weight (lbs)	Diameter (in)	Length (in)
2684Z	70	2.7	84

5. Anode Lead Wire Connection:

- a. Lead Wire:
 - (1) #8 AWG stranded, copper conductor with high molecular weight polyethylene (HMWPE).
 - (2) Length: Sufficient to reach the anode junction box without splicing additional wire.
- b. Attach at the center of the anode.
- c. Minimum pull-out strength: 1-1/2 times the breaking strength of # 8 AWG lead wire or 788 pounds for the center connection.
- d. Do not exceed 0.004 ohms for electrical contact resistance as measured across lead wire-to-connector junction.

D. Anode Backfill:

1. Provide sufficient coke breeze to backfill completely around anodes as shown on Drawings with allowances for extra volume due to cave-ins, wash-outs, and excavation or installation methods.
 - a. Coke breeze for backfill of groundbeds: Low resistance (less than approximately 0.10 ohm-cm), electrically conductive, calcined petroleum type approved for direct burial by the appropriate federal, state, and local agencies.

Element	Composition, Weight %
Volatile Matter	0.7 to 1.8% maximum
Ash	2.3% maximum
Sulfur	5.9% maximum
Actual Carbon	91.0% minimum
Particle Size	85% less than ¼-inch
Bulk Density	55 to 60 pounds per cubic foot minimum
Fixed Carbon (Carbon and Sulfur)	96.0% minimum

- b. Coke breeze for deep anode type groundbeds:
 - (1) Sources: LORESCO DW-1, SC-2, or SC-3 or approved equal.
 - (2) Suitable for pumping.
 - (3) Calcined.

E. Downhole Vent Pipe for Deep Anode Groundbeds (vent pipe through active column):

1. Material:
 - a. Heavy duty Schedule 40 PVC.
 - b. Diameter: Minimum one inch.
 - c. Conforming to ASTM D 1785, Type 1, Grade 1.
 - d. Resistant to chlorine.
2. Extended from the bottom to the top of the drilled hole.

3. Perforated in a continuous manner such that perforated sections are adjacent to anodes for the entire active anode column length upon installation.
4. Either drilled and provided with geotextile fabric sock or slotted.
5. Seal the bottom of the vent pipe with a plastic end cap or plug.
6. Drilled vent pipe holes:
 - a. Diameter: 3/8-inch.
 - (1) Penetrate pipe at four quadrants around the circumference at each drilled location and space equally at 4 inches apart throughout each perforated 2-foot section.
 - (2) Wrap in geotextile fabric sock to prevent intrusion of fine-grained coke breeze into vent pipe.
 - (a) Source: Nilex filter sock.
 - (b) Description: Non-deteriorating geotextile material of sufficient durability and attachment to the pipe to resist tearing and damage during installation.
 - (c) Securely fasten to drilled plastic pipe by means of two complete wraps of tape at each end of 20-foot pipe section.
7. Slotted vent pipe:
 - a. Source: All Vent by Loresco.
 - b. Description: Vertical slits approximately 0.006-inch wide and 1 1/2 inches long cut in a parallel pattern to longitudinal centerline of the plastic pipe.
 - c. Slot spacing: One-inch from preceding slit at approximately 6-inch centerline separation distance.

F. Well Casing:

1. Use when required due to subsurface conditions or environmental sealing requirements are necessary. Do not install well casing in active column of deep anode groundbed unless approved by Owner or Designated Representative.
2. Material:
 - a. Standard weight steel or plastic.

- b. Plastic casing: Meet or exceed ASTM F-480.
 - c. Good condition, durable, and watertight.
 - d. Nontoxic and resistant to water and soil corrosiveness.
 - e. Meet local well drilling standards and withstand installation, grouting, and operating stresses.
 - f. Nominal wall thickness for 6 inch or larger diameter steel casing: 0.25-inch thick.
3. Sealing Material:
- a. Impermeable material, such as bentonite-gelatinous mud or grout or puddling clay as required to meet local and state drilling code requirements.
 - (1) Bentonite Sealer:
 - (a) Sources: PermaPlug by Cathodic Engineering Equipment, Co., Inc., Enviroplug by Mesa or approved equivalent.
 - (b) Description: High swelling, chemically unaltered bentonite clay intended for plugging and sealing drilled holes.
 - (2) Puddling Clay Sealer:
 - (a) Mixture of bentonite, other expansive clays, fine-grained material and water, in a ratio of no less than 7 pounds of bentonite or expansive clay per gallon of water.
 - (b) Composed of a minimum of 50% expansive clay with the maximum size of the remaining portion not exceeding that of coarse sand.
- G. Gravel for Deep Anode Groundbed:
- 1. Use if allowed by state regulation.
 - 2. Description: 3/4-inch thoroughly washed, sound, durable, and well- rounded gravel.
- H. Deep Anode Surface Vent Pipe (vent pipe through inactive column and surface):
- 1. One-inch diameter PVC pipe with 180° gooseneck.

2. Install cap with ¼" drilled holes or screened fitting on end of gooseneck for ventilation of the deep anode system.
3. Install and terminated at the top of surface casing as shown on Drawings.

I. Anode Junction Box:

1. Sources: Integrated Rectifier Technologies.
2. Description: NEMA 3R, vented steel type junction box, standard product of the recognized manufacturer.
3. Material: Minimum 16-gauge steel.
4. Minimum inside box dimensions: 12-inch x 12-inch x 6-inch deep or larger, if required to provide proper access for the number of anodes specified.
5. Finish: Coating to match rectifier. Galvanized or coated with either baked enamel or heat-cured 100% solids thermosetting epoxy coating.
6. Provide with:
 - a. One-piece of oil resistant gasket to be mounted inside the door to form an oil-tight and dust-free seal.
 - b. A locking lid and a hasp for a padlock.
 - c. Separate panel board:
 - (1) For the attachment of a busbar with a terminal strip or terminal block with medium-duty solderless compression type terminal connectors.
 - (2) Accommodate the anode wire and the rectifier positive header wire gauge specified with the necessary mounting hardware.
 - (3) Material: A minimum 3/16-inch micarta or cross-laminated phenolic sheet.
 - d. Sufficient copper shorting bars and/or 0.01 ohm Holloway "Type RS" shunts to electrically bond each anode lead terminal to the rectifier positive lead busbar as shown on Drawings.
 - e. A minimum number of shunts and compression type connectors to match the number of anodes provided for each groundbed location.

- f. Rugged supports on the enclosure to allow it to be securely wall- mounted if needed.
- g. Double hub suitable for thread mounting on two 1-1/4 inch or larger rigid threaded galvanized steel conduit.

J. Negative or Cross Bond Station Junction Box (if required):

- 1. Sources: Integrated Rectifier Technologies
- 2. Description: NEMA 3R, vented steel type junction box, standard product of the recognized manufacturer.
- 3. Material: Minimum 16-gauge steel.
- 4. Minimum inside box dimensions: 12" L x 12" W x 6" D or larger, if required to provide proper access for the number of resistors and structure wires specified.
- 5. Finish: Coating to match rectifier. Galvanized or coated with either baked enamel or heat-cured 100% solids thermosetting epoxy coating.
- 6. Provide with:
 - a. One-piece of oil resistant gasket to be mounted inside the door to form an oil-tight and dust-free seal.
 - b. A locking lid and a hasp for a padlock.
 - c. Separate panel board:
 - (1) For the attachment of a busbar with a terminal strip or terminal block with medium-duty solderless compression type terminal connectors.
 - (2) Accommodate the resistors and the rectifier negative header wire gauge specified with the necessary mounting hardware.
 - (3) Material: A minimum 3/16-inch micarta or cross-laminated phenolic sheet.
 - d. Minimum size and quantity of slide resistors connected to the negative busbar as shown on Drawings.
 - e. Sufficient copper shorting bars and/or 0.01 ohm Holloway "Type SW" shunts to electrically bond each structure to the resistor as shown on Drawings.

- f. A minimum number of shunts and compression type connectors to match the number of structures provided for each bond location.
- g. Rugged supports on the enclosure to allow it to be securely wall-mounted if needed.
- h. Double hub suitable for thread mounting on two 1-1/4 inch or larger rigid threaded galvanized steel conduit.

K. Hardware:

- 1. Flat and lock washer, terminal nuts, and studs: 1/4-inch.
- 2. Finish: Nickel-plated brass or bronze.

L. Conduit, Locknuts, and Straps:

- 1. Use intermediate threaded metal conduit, including couplings, elbows, nipples, and other fittings, hot-dipped galvanized that meet the requirements of UL and the NEC.
- 2. Heavy wall, rigid, PVC conduit:
 - a. Schedule 40.
 - b. UL listed for concrete encasement, underground direct burial, concealed, and direct sunlight exposed usage.
- 3. Flexible non-metal conduit:
 - a. UL listed.
 - b. Liquid-tight flexible non-metallic conduit consisting of an extruded PVC jacket and terminated with nylon bushings with steel or malleable iron body and insulated throat and sealing O-ring.
- 4. Locknuts, two-hole straps, and other miscellaneous hardware: Hot-dipped galvanized in accordance with ASTM A153.
- 5. Conduit bushings: Threaded plastic or plastic-throated galvanized steel fittings.

M. Enclosures:

- 1. NEMA 3R, 6' long x 6' tall x 4' wide, 12-gauge carbon steel enclosure with fully welded seams as manufactured by Bison ProFab Industrial Enclosures.

2. Enclosure shall have 6' wide, French style, full opening doors on each side for access. Double flanged door openings shall be sealed with neoprene gaskets and contain 3-point stainless steel pad lockable Defeater handles with stainless steel rods and nylon rollers.
3. 12" x 12" door pocket bolted to inside of each door
4. Door shall have hidden hinges with stainless steel hardware spot welded to each door.
5. Enclosure shall include four (4) 5/8-11 stainless steel lifting eye bolts installed and sealed to NEMA 3R on roof with channel stiffeners for lifting.
6. Enclosure shall include 12" wide x 18" tall louver panels installed on each side opposite of adjacent doors. Louver panels shall contain a screen mesh permanently secured to the enclosure on the inside of each panel area.
7. Interior and exterior of enclosure shall be painted with Desert Tan coating. Exterior shall have a clear anti-graffitti overcoat applied.
8. Pad locks (either 4-digit combo or keyed) will be provided by the Owner or Designated Representative.

N. Test Stations:

1. Post style:
 - a. Gerome Electric, Model 917, 7 Terminal, Threaded 3" Top
 - (1) Terminal board hardware shall consist of stainless steel or nickel-plated brass and consist of a minimum of seven (7) ½ inch diameter by 1.25 inches long studs with double nuts, flat washers, and lock washers.
 - b. Gerome Electric, Model 2015, 15 Terminal, Threaded Top.
 - (1) Use 3" to 2" threaded reducer to attach to galvanized post.
 - (2) Terminal board hardware shall consist of stainless steel or nickel-plated brass and consist of a minimum of seven (7) ½ inch diameter by 1.25 inches long studs with double nuts, flat washers, and lock washers.
 - c. Support Post: 3.5" Galvanized Painted Rigid Steel, Threaded One End, 6' Long

- d. Labels: Install label tags on all wires
 - (1) Pipe Diameter and material, as applicable
 - (2) Wire Function
 - (3) Posts shall include reflective bands and labels.

2. Flush Style:

- a. Oldcastle Christy, Model G05 with 3" diameter Cott Big Fink model test head inside, cast iron cover labeled 'C.P. Test'.
 - (1) Terminal board hardware shall consist of stainless steel or nickel-plated brass and consist of a minimum of seven (7) ½ inch diameter by 1.25 inches long studs with double nuts, flat washers, and lock washers.
 - (2) Test station head shall have 3" PVC threaded collar and cover
- b. Labels: Install label tags on all wires with the following:
 - (1) Pipe Diameter and material, as applicable
 - (2) Wire Function

O. Galvanic (Magnesium) Anodes:

- 1. Magnesium anodes shall be Hi-Potential, ASTM B843, Grade M1C and conform to the following specifications:

ALUMINUM (AL)	0.10% MAXIMUM
MANGANESE (MN)	0.50 TO 1.30%
ZINC (ZN)	0.005% MAXIMUM
COPPER (CU)	0.02% MAXIMUM
NICKEL (NI)	0.001% MAXIMUM
IRON (FE)	0.03% MAXIMUM
OTHER IMPURITIES – EACH	0.05% MAXIMUM
TOTAL	0.30% MAXIMUM
MAGNESIUM (MG)	BALANCE

2. Circuit Potential and Electrochemical Capacity: Open circuit potential of 1.50 volts or more negative in reference to a copper-copper sulfate reference electrode.
3. Anode Backfill:
 - a. Anodes shall be furnished prepackaged in special backfill material consisting of 75% ground hydrated gypsum, 20% powdered bentonite and 5% anhydrous sodium sulfate.
 - b. The backfill shall have a grain size such that 100% is capable of passing through a 20-mesh screen and 50% will be retained by a 100- mesh screen. The backfill mixture shall be firmly packaged around the anode within a cotton bag by means of adequate vibration.
4. Anode Lead Wire:
 - a. No. 12 AWG solid copper conductors with RHW/USE-2 insulation.
 - b. Black insulation.
 - c. Lead wires shall be a minimum of 50 feet in length. The lead wires shall be connected to the galvanized steel core of the anode by silver soldering and sealed with waterproof epoxy or electrical potting compound.
 - (1) Sufficient in length to reach test station without being spliced.
5. Dimensions: Minimum bare weight of 32 lbs with an ingot length of 19 7/8 inches or sized as per detail drawings.
6. Anodes shall be shipped in waterproof bags or wrapping and shall remain dry until installation.
7. Acceptable Manufacturers:
 - a. Farwest Corrosion Control (Denver, CO) or MESA (Denver, CO)
 - b. Owner or Designated Representative approved equal.

P. Stationary Reference Electrodes:

1. Copper/copper sulfate reference electrode material designed for minimum 20-year useful life as manufactured by GMC Electrical.
2. Reference electrode to be pre-packaged with a low resistivity backfill formulated to retain moisture and maintain stability.

3. Reference electrode shall contain one (1) #14 RHW/USE-2 yellow lead wire for connection. Recommend 50 feet minimum.

Q. DC Metallic Coupons:

1. Suitable sized metallic with a minimum exposed surface area of 1.55 square inches (10 cm²) as manufactured by McMiller Co. Inc.
2. Coupon shall contain two (2) #12 AWG THHN/THWN green cables for connection.
3. Ensure metallic coupon is the same material and composition as the structure under cathodic protection. Recommend 50 feet minimum.

R. Exothermic Welds:

1. All electrical cable connections to the buried piping shall be made by an exothermic weld.
2. Exothermic type weld materials including the proper size and type of weld cartridges and welder molds for use on ductile-iron or steel pipe.
3. Acceptable Manufacturers:
 - a. Erico Products Inc. "CADWELD PLUS"
 - b. Owner or Designated Representative approved equal.
4. Weld materials shall be compatible to the pipe material as recommended by the manufacturer.
5. Copper sleeves specifically designed for the purpose of exothermic welding shall be crimped on all bare wire ends of #10 AWG or smaller gauge wires prior to exothermic welding to improve mechanical strength and thermal capacity.

S. Di-Electric Coatings:

1. Denso Protal 7125 repair coating or Owner or Designated Representative approved equivalent.
2. All waterline pipe and pipe fittings shall be furnished with a factory applied coating as specified in other sections. The factory applied coatings shall be inspected prior to installation and shall be installed in accordance with the manufacturer's recommendations.
3. All bare line pipe, uncoated flange bolts, uncoated mechanical fitting bolts, and other uncoated bolts, nuts, flanges, or fittings with metallic composition shall be

protected with wax-tape primer and #1 wax-tape as manufactured by Trenton Corporation or approved equivalent and applied to a thickness of 20 mils.

T. Plastic Conduit for Cathodic Protection Sheathing (below grade applications):

1. Diameter: Sized to match application.
2. Schedule 40 polyethylene (PE) or polyvinyl chloride (PVC) plastic pipe.

U. Wire:

1. Insulated stranded or solid copper wire as specified.
2. Wire size, type, and insulation type: As specified in this Section and as depicted on the Drawings:
 - a. Structure Connections to Rectifier: #4 AWG, Stranded HMWPE
 - b. Anode Junction Box to Rectifier: #2 AWG, Stranded, HMWPE
 - c. Groundbed Anodes to Anode Junction Box: #8 AWG, Stranded, HMWPE
 - d. Joint/Continuity Bonds: Size per table on Drawings, Stranded, RHW
 - e. Pipe Test Leads: #8 AWG, Stranded, RHW
 - f. Galvanic Anode Leads: #12 AWG, Solid, RHW
 - g. Reference Electrodes: #14 AWG, Stranded, RHW
 - h. Metallic Coupons: #12 AWG, Stranded, THHN/THWN
3. Wire insulation color: Indicate the function of each wire as shown on the Drawings.
 - a. Red: Anode Junction Box to Rectifier
 - b. Blue: Test Leads for Owner or Designated Representative (Project) Pipe
 - c. White: Test Leads for Future or Foreign Pipelines
 - d. Black: Structure/Negative cables, anode leads, and joint/continuity bonds
 - e. Yellow: Reference electrode
 - f. Green: DC metallic coupon
 - g. Orange: Casing pipe or tunnel lining

4. AC wire to supply power to rectifier:
 - a. Single conductor, soft drawn copper.
 - b. Minimum No. 10 AWG or larger as sized in accordance with (NEC) to match the maximum rated rectifier power requirement.
- V. In-Line Tap Slices for Cathodic Protection Cables (use only if approved by Owner or Designated Representative):
 1. "C" taps made of conductive wrought copper.
 2. Sized to fit the wires being spliced.
 3. Apply compression connectors the proper crimp tool and die recommended by the manufacturer for the wire and the tap connector size; in-line
 4. "Butt" type wire splice connectors are acceptable for #8 AWG or smaller splices.
 5. Electrical Splicing Tape and Coating:
 - a. Acceptable manufacturers:
 - (1) Scotch 130C tape
 - (2) Scotch Super 88 tape
 - (3) Scotchkote Electrical Coating as manufactured by 3M Products
 - (4) Owner or Designated Representative-approved equal.
 - b. 30 mil liner-less rubber high voltage splicing tape and 7 mil vinyl electrical tape suitable for moist or wet environments.
 - c. Electrical Connectors: Tin or nickel-plated copper, brass, bronze, or stainless steel for electrical conductivity and atmospheric corrosion resistance.
- W. Wire Terminals
 1. Burndy YAV series.
- X. Test Station Shunts
 1. 0.01 ohm, yellow
 2. Acceptable Manufacturers:

- a. Cott.
- b. Owner or Designated Representative-approved equal.

Y. Wax Tape:

1. Design:

- a. A blend of microcrystalline waxes, plasticizers and corrosion inhibitors saturated into a non-woven, non-stitch bonded synthetic fabric, forming a tape wrapper.
- b. Shall contain no siliceous mineral fillers.
- c. Suitable for below ground use
- d. Nontoxic, nonflammable, non-carcinogenic, free of all VOCs

2. Acceptable manufacturers:

- a. Trenton, #1 Wax-Tape.
- b. Owner or Designated Representative-approved equal.

Z. Polyethylene Wrap:

- 1. High density, cross-laminated polyethylene film, 4-mil thickness.

AA. Wire Labeling:

1. Design:

- a. Wire labeling shall be permanent, heat shrinkable sleeves.
- b. Shall be weather resistant/UV light resistant with matte finish.
- c. Install marking sleeve within 6" of termination. Marking sleeve shall be clearly visible.

2. Acceptable Manufacturers:

- a. Epson LabelWorks
- b. Owner or Designated Representative approved equal.

BB. CP Warning Tape:

1. 1. 3" plastic, APWA blue, non-detectable, marked "Caution Cathodic Protection Cable Buried Below".

CC. Electrical Isolation Devices:

1. Electrical isolation of the buried piping shall be accomplished by flange isolation kits, insulating mechanical couplings, di-electric unions, or a piece of non-metallic piping where specified herein or shown on the Drawings. In the event an insulating coupling is restrained using harness rods, each rod shall be insulated using a properly sized one-piece insulating sleeve and washer with steel backing washer.
2. Flange isolation kits shall be ordered according to pipe size and pressure rating of the flange and shall be installed per the manufacturer's instructions. Care shall be exercise so as not to damage the insulating bolt sleeves and washers.
3. Required applications of dielectric flange isolation assemblies, couplings, and other devices are not limited to selected locations where new piping is mechanically connect to existing piping. Other such examples include:
 - a. Transfer of Ownership locations.
 - b. Connections between dissimilar metals (i.e. welded steel to ductile).
 - c. Cased segments of piping.
 - d. Connections to electrically grounded components such as actuated valves, meters, pump stations, processing facility, and other structures.
 - e. Concrete encased segments of piping such building risers and valve vault penetrations.
4. Materials:
 - a. Di-Electric (Insulated) Unions
 - (1) Approved manufacturers:
 - (a) Hart Industrial Unions with thermo baked epoxy polymer coating of 3 to 6 mils on tailpiece.
 - (b) Owner or Designated Representative-approved equal.
 - b. Insulating Mechanical Couplings:
 - (1) Approved manufacturers:

- (a) Dresser "Style 39"
- (b) Rockwell "416"
- (c) Romac "IC501"
- (d) Baker "Series 216" without pipe stop
- (e) Owner or Designated Representative-approved equal.

c. Insulating Flange Gaskets

- (1) Provide G-10 Glass Reinforced Epoxy Retainer with appropriate seal based on type of product, Type 'E' full face gasket as manufactured by GPT Industries, or Owner or Designated Representative approved equivalent.

d. Insulating Sleeves and Washers

- (1) Provide full length G-10 sleeves with G-10 or Diamond Hyde washers as manufactured by GPT Industries, or Owner or Designated Representative approved equivalent.
 - (a) For direct buried applications, install single washer sets on the existing or uncathodically protected side of the isolation flange or coupling so that the metallic flange bolts, restraining rods, nuts, and washers are electrically continuous with the new or cathodically protected piping.
 - (b) For above grade or vaulted applications, install double washer sets.

- 5. Coat all bare, buried di-electric components to include nuts, bolts, and washers with wax-tape primer and #1 wax-tape as manufactured by Trenton Corporation or approved equivalent and applied to a thickness of 20 mils.

DD. Concrete Encasement for Corrosion Control:

1. Concrete materials:

- a. Conform to ASTM C94-90, Option A, and ASTM C 150.
- b. Concrete shall be Type II with a minimum cement content of 564 pounds per cubic yard.
 - (1) Aggregate size; $\frac{3}{4}$ -inch or smaller

- c. Minimum compressive strength of 3,000 psi at 28 days with a maximum water-cement ratio of 0.45.
 - d. Air Entrainment:
 - (1) ASTM c 260, nontoxic after 30 days and contain no chlorides.
 - (2) Not less than 5% entrained air at the project site.
2. Piping materials:
- a. Each concrete encased segment of piping shall be bare except for a 12-inch coating overlap at each end of the encasement. The 12 inch coating overlap shall consist of a bonded coating system such as polyurethane or fusion bonded epoxy.

PART 3 - EXECUTION

3.01. GENERAL

- A. Complete anode assembly, wire connections, splices, anode placement, coke breeze installations, and backfill operations during daylight conditions.
- B. Install corrosion protection system components, such as splices, bonds, and wire installation when ambient temperature is above 15°F and rising in order to minimize damage to materials and insulation.
 - 1. Bury all cathodic protection wiring, conduits, and other components with a minimum of 24-inches of cover or a minimum of 36 inches for agricultural areas.
 - 2. Do not Cadweld or utilize open flame or torches in areas of flammable vapors or airborne particles where a fire or explosion could result.
 - 3. Install and work around above grade and buried AC power lines and oil and gas pipelines with extreme care; follow the minimum separation distances in accordance with foreign company requirements and regulations. Contractor is required to identify and notify all foreign owners of pending construction and schedule of when line crossings will occur.
 - 4. Do not work next to power lines during times of high lightning activity.
 - 5. Changes to the locations of components due to field conditions must be approved in writing by Owner or Designated Representative.

3.02. INSTALLATION

A. Deep Anode Groundbed:

1. Perform drilling, electrical logging of hole, lowering of anodes, coke breeze placement, and backfilling in one continuous operation.
2. Ensure process is observed by the Owner or Designated Representative, and Contractor's NACE CP Specialist (CP4) or their duly appointed representative in prescriptive method that follows.
3. Submit procedures if alternate methods are used.
4. Construct holes and set casings round, straight, and plumb.
5. Seal as specified herein or as required by local well drilling regulations or the State Water Resources Board; the most stringent requirements shall apply.
6. Take necessary precautions to avoid contamination of the aquifer with contaminated water, gasoline, drilling fluids and additives, or other deleterious substances during construction, through opening, or by seepage through ground surface.
7. For deep anode groundbeds, maintain a log describing depth and type of geological formations encountered during drilling; submit copies of the log to the Owner or Designated Representative and the appropriate authorities.
8. Take precautions to avoid entrance of foreign matter into the hole, movement of soil strata, or collapsing of the hole at all times during progress of Work.
9. Should movement of soil strata or collapse of drilled hole interfere with proper installation occur, recover wire and anode strings and ream or redrill hole as possible. If not possible, consult Owner or Designated Representative.
10. Drilling:
 - a. Drill a minimal nominal depth as shown on the Drawings.
 - b. Over-drill the hole depth as required to compensate for sloughing during anode installation such that top of the active column is not less than the minimum separation distance below the ground surface as shown on the Drawings.
 - c. Drill fluid: Non-hazardous, bentonite based, water well type drilling gel or mud.

- d. Drilling mud: Certified by National Sanitation Foundation (NSF) as non-hazardous.
- e. Locations:
 - (1) Drill at the approximate locations shown on the Drawings.
 - (2) Exact locations will depend on the locations of structures and utilities encountered in field and must be determined in the field with the approval from the Owner or Designated Representative prior to the start of construction.
- f. Over-drill hole and install surface casing as shown on the Drawings:
 - (1) Do not install casing, other than surface casing, unless necessary for successful completion of hole.
 - (2) Set surface casing prior to completion of the first 50 feet of the hole.
 - (3) Should steel casing be installed, jack up to point 5 feet, minimum, above the top of the active column.
 - (4) Complete cutting and jacking operations before or after the installation of the anode assembly.
 - (5) Plastic casing may be installed in the inactive column area.
 - (6) Install the surface casing such that a minimum of 3 feet remains above grade.
 - (7) Sealing:
 - (a) Seal annular space around surface casing and soil in accordance with state requirements and local well drilling regulations.
 - (b) Allow sealing material to reach initial set before any additional work on the drilled hole that may disturb the seal will be allowed to continue.
 - (c) Seal hole to prevent downhole movement of surface water and the intermixing of different aquifers.
 - (d) Where separate aquifers are encountered, install a bentonite seal between the different aquifers as per local well drilling

regulations or the State Water Resources Board; the most stringent requirements shall apply.

- (e) Bentonite seal thickness: Minimum 5 feet or as per local well drilling regulations or the State Water Resources Board; the most stringent requirements shall apply.
- (f) Increase seal thickness as required to maintain the separation of aquifers under high pressure or artesian conditions.
- (g) If different aquifers are encountered in active anode area, install separate vent pipes in areas between different aquifers.

- g. Contain and dispose of drilling mud and cuttings in a legal manner.
- h. Field dug mud pits or sumps are acceptable depending on the location and prior written approval of the Owner or Designated Representative, jurisdiction, and the potential landowner(s).
- i. Field mud pits will only be considered, if completely pumped and cleaned out following drilling operations and backfilled and compacted correctly so as to not cause settlement or soft areas in future.

11. Anode Bed Loading Preparation:

- a. Give the Owner or Designated Representative a minimum of 72 hours' notice prior to final anode hole preparation and anode and coke breeze placement.
- b. Complete the final preparation of the anode hole, electrical logging, lowering of anodes and vent pipe, coke breeze backfill, and placement of seals only during daylight hours and when observed by the Owner or Designated Representative.
- c. When holes have been drilled to the specified depth, circulate clean water in the hole to clear of drilling mud and cuttings.
- d. Recirculate sufficiently to allow settling of coke breeze without causing danger of anode hole collapse or wall sloughing.
- e. Maintain the hole full of water during anode and coke breeze placement.
- f. Schedule work of anode bed loading preparations early enough in the day to insure completion during normal working hours.

- g. Do not begin flushing and anode loading after 2:00 p.m. without prior written approval.

12. Lowering of Anodes:

- a. Lower anodes after drilling and the Owner or Designated Representative's review of the driller's log and the electrical logging of the hole are completed.
- b. The actual lowering of anodes and backfilling of hole with coke breeze shall be observed by the Owner or Designated Representative.
- c. Delay installation of anode assembly and coke breeze until next day if it cannot be completed during daylight of same day as completion of drilling and electrical loggings.
- d. If installation of the anode assembly is delayed more than 4 hours from completion of drilling operations, reinsert drill stem and bit and run back to the bottom of the hole.
- e. Maintain sufficient bit rotation and circulation to ensure the drilled hole is adequately prepared for anode and coke breeze installation.
- f. Maintain the hole full of water during the installation of the anodes and coke breeze.
- g. Lay out anode leads and vent pipe to prevent damage, allow inspection, and to allow ease of downhole installation.
- h. The Contractor will be responsible for inspecting anodes and lead wires for damage prior to installation. Damage to anodes or lead wires is cause for rejection of that anode assembly.
- i. Measure the anode lead wire length to verify and monitor actual anode depth and spacing in drilled hole by either of the following methods:
 - (1) Measure anode lead length as the individual anode is lowered down the hole with a wire measurer to confirm actual anode elevation and spacing.
 - (2) Pre-measure the anode length and compare it to other anode lengths for reference; lay out anode leads, measure actual anode wire length, and pre-mark them to demonstrate actual wire lengths and show that difference between ends of wires are equal to specified spacing.

- j. If the vent pipe is predrilled, encase in geotextile sock and secure sock with tape on each end of vent pipe.
- k. If slotted vent pipe, geotextile sock is not required.
- l. For deep anode groundbed, attach first, the deepest anode to the pre-drilled or slotted vent pipe; seal vent pipe with a cap or plug.
- m. After electrical logging has been completed, carefully lower the anode and the vent pipe to the bottom of the hole.
- n. Wipe vent pipe individual ends clean and dry, and glue with solvent type cement.
- o. Solvent type cement: Designed to be suitable for similar fast set, immersion service, and joining of PVC.
- p. Clean glue, rotate the connection, and allow to sufficiently dry before the vent pipe is lowered.
- q. Lower remaining anodes individually.
- r. Monitor individual anode depth and spacing.
- s. Maintain sufficient slack in the anode lead cables to prevent damage during anode installation and backfilling operations.
- t. When the anode is at the specified depth, suspend in the hole and securely tie off around the suspension bar or the pipe with a sufficient diameter 2-1/2 inches minimum, to prevent sharp bending of wires.
- u. Tie wires off in order.
- v. Keep anodes securely fastened until the coke breeze backfill has been placed and has settled.
- w. Take care to avoid damage to anode assembly and wires from casing or drill rig.
- x. During installation, if any anode is damaged or wire insulation is cut, gouged, or scraped, the anode and wire will not be acceptable.
- y. No wire splices will be allowed except those shown on Drawings and approved by the Owner or Designated Representative.

- z. Elevation and spacing of anodes shall be as shown on Drawings unless the Engineer modifies the anode depth and spacing in the field based on the driller's geological log and electrical log.
- aa. If directed, modify anode elevation by installing a gravel layer below the first anode or over-drilling the hole.
- bb. If needed, flush the hole to allow for the installation and settlement of gravel layer for anode location adjustment.

13. Backfilling of Anode Hole:

- a. After the anode assembly is installed to the predetermined depth, place coke breeze column around anodes by pumping.
- b. Leave the hole full of water for backfilling.
- c. Thoroughly mix with water to prepare coke breeze slurry in accordance with the manufacturer's written recommendations.
- d. Pump coke breeze slurry in the hole at high pressure through an additional plastic pipe or flexible hose.
- e. Install pumping pipe or hose in the drilled hole before or after the first anode and vent pipe assembly is installed in drilled hole, but before the remaining anodes are installed.
- f. Pump in an even and continuous manner around each anode from the bottom of the hole to the top as the pipe is slowly and carefully withdrawn.
- g. Take care not to stick pipe or to remove pipe too fast.
- h. Continue the pumping operation in continuous operation when started.
- i. Install a sufficient amount to cover the top anode as shown on Drawings.
- j. Conduct resistance measurements between the appropriate grounded structure or pipeline and each individual anode lead as coke breeze is pumped into the drilled hole.
- k. Start individual anode resistance measurements with the bottom anode first.

- l. When the resistance measurement indicates that coke breeze level has covered the first anode, connect the test leads to the next higher anode lead wire and repeat the resistance measurement.
- m. Conduct resistance testing consecutively for each anode as the coke breeze is installed.
- n. Utilize resistance measurements to monitor coke breeze level in the drilled hole and detect any possible coke breeze bridging problems during the pumping process.
- o. After the coke breeze has been placed and settled and anodes have become substantially set, measure the electrical resistance of individual anodes again, to verify that no bridging occurred.
- p. Measure, record, and submit initial and final individual anode resistance-to-earth for each drilled location.
- q. Take care to not damage the anode assembly and to avoid plugging the vent pipe, bridging of coke breeze, collapsing of the hole, and either over-filling or under-filling the hole.
- r. If the hole collapses, coke breeze bridges, vent pipe plugs, anode assembly is damaged, or the hole is under-filled, or over-filled, take necessary steps to resolve and correct the problem at the Contractor's sole expense.
- s. After the coke breeze is installed and has settled for a minimum of 12 hours and anodes are set, measure the depth to the top of coke breeze column to ensure coke breeze is at specified elevation in order to maintain sufficient cover for anodes and electrical isolation from the structure to be protected.
- t. If the hole is over-filled by more than 15 feet, remove coke breeze to provide specified elevation.
- u. If the hole is under-filled by more than 5 feet, add additional coke breeze to the specified elevation by hand shoveling a saturated mixture of coke breeze and water to bring the coke breeze level up to specified depth.
- v. Upon acceptance of the coke breeze installation, either add 3/4-inch diameter of washed gravel, if allowed by state regulations, or drill cuttings or bentonite clay to fill the hole to depth shown on the Drawings

14. Placement of Seal:

- a. Upon acceptance of washed gravel or top coke breeze elevation, place sealing material from the top of the gravel backfill or coke breeze to a point either 12 inches below the finished elevation of well seal or hole termination depth shown on the Drawings or as required by local, county, or state well drilling regulations.
 - b. The method of seal placement shall force the sealing material from the bottom of the space to be sealed to the surface.
 - c. Place sealing material in a manner that ensures entire the filling of the space in one continuous operation.
 - d. Complete vent pipe and lead wire termination prior to the placement of the seal inside the casing.
15. Vent Pipe Termination:
- a. Terminate the vent pipe 3 feet above grade and out the top of the well casing so that the opening for the vent pipe is facing downward. Other locations may be approved by the Owner or Designated Representative.
 - b. Install a 180° gooseneck on the vent pipe and cap with predrilled end cap or screened bushing.

B. Rectifier:

- 1. Provide rectifier, entrance, switch, and electrical hardware.
- 2. Conform to NEC electrical codes, local utility company requirements, permitting agencies, and applicable codes and standards.
- 3. Installation and locations as shown on Drawings.
- 4. Mounted to allow unobstructed access to and full opening of rectifier access doors for testing, maintenance, and repair.
- 5. Submit location adjustments in writing for review and approval by the Owner.
- 6. Install level and plumb.
- 7. Install rectifier cables in rigid galvanized steel conduit or PVC.
- 8. Terminate conduits with plastic-throated conduit bushings.
- 9. Identify with a stamped identification tag permanently attached in a visible location on the inside of the rectifier housing.

10. Install rectifier wire from the rectifier negative terminal directly to the pipelines or through a junction box as shown on Drawings. Install a minimum of two (2) negative cables per pipeline.
11. Install rectifier wire from the rectifier positive terminal to the anode junction box or the anode header wire as shown on Drawings.
12. Clearly identify ground bed (anode) and structure leads in the rectifier case and boxes.

C. Remote Monitoring Unit:

1. Conform to NEC electrical codes, local utility company requirements, permitting agencies, and applicable codes and standards.
2. Installation and locations as shown on Drawings.
3. Mounted to allow unobstructed access to and full opening of remote monitor unit access doors for testing, maintenance, and repair.
4. Submit location adjustments in writing for review and approval by the Owner or Designated Representative.
5. Install level and plumb.
6. Install remote monitor cables in rigid galvanized steel conduit or PVC.
7. Terminate conduits with plastic-throated conduit bushings.
8. Install a 100-amp mercury relay as per manufacturer's instructions.
9. If installed within a closed area, orient satellite receiver outside of building or obstacles and provide a clear, unobstructed view for communication signal.
10. Connect AC power to the remote monitor unit via a step-down transformer as provided by remote monitor manufacturer.

D. Rectifier Conduits and Junction Boxes:

1. Install above-grade conduit, fittings, and wires in rigid hot-dipped galvanized steel conduit or rigid PVC conduit, as indicated on Drawings. If less than 3 feet long, flexible liquid-tight non-metallic conduit is suitable.
2. Secure with double hole conduit straps with wood screws on wood bolts and expansion shields on concrete or brick, toggle bolts on hollow masonry units, and machine screws or welded, threaded studs on steelwork.

3. Install below grade wires in rigid PVC conduit and fittings.
4. Mount boxes and exposed conduit plumb and level.
5. Install in a secure, substantial manner by attachment to the appropriate wood post, channel, service pole, building structure, or structural member.
6. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
7. Secure conduits entering cabinets, junction, or terminal boxes with double galvanized locknuts, one on the inside and one on the outside of the box and with bushings.
8. Size conduit in accordance with appropriate codes and such that conductors may be drawn in without injury or excessive strain.
9. In outdoor, underground, or buried locations, use watertight couplings, and connections.
10. Open no more knockouts in box than required. Seal unused openings.
11. Install to prevent water from entering the conduit or the box.
12. Install insulated bushings and insulating throat connectors on the ends of rigid metallic conduit that terminate in test stations, junction or terminal boxes, and rectifier cabinets.
13. Make conduits watertight and free of obstructions.
14. Ream conduits, remove burrs, and clean the conduit interior before introducing cables or pull wires.
15. For plastic conduits, use factory made elbows for bends 30° or larger.
16. Make no bends in flexible conduit that exceed the allowable bending radius of the cable to be installed or that significantly restricts conduit flexibility.
17. Solvent weld plastic conduit joints with solvent that is recommended by the conduit manufacturer.
18. Follow the manufacturer's written instructions and provide watertight joints.
19. Provide expansion joints as required or as recommended by the conduit manufacturer.

20. Use acceptable plastic terminal adapters and female adapters when joining plastic conduit to metallic fittings or conduit.

E. Enclosures:

1. Enclosures to be installed over all impressed current rectifiers and junction boxes. AC power components, groundbed vent piping, and groundbed surface casing shall be installed outside of any enclosure.
2. Install enclosure on 7' long x 5' wide concrete pad with a minimum thickness of 6 inches, centered on the electrical rack and components.
3. Concrete pad:
 - a. Ensure all conduits, posts, and other items are at their proper location and elevation prior to pouring concrete pad.
 - b. Install a minimum 1" poly foam around all conduit and post penetrations as a bond breaker from the concrete pad or install flexible connections to all equipment for frost heave and movement.
 - c. Prep pad area by removing a minimum of 3" of subgrade and compact area with a walk behind or hand compactor. Putting in compaction effort will go a long way toward a long service life.
 - d. Concrete pad shall consist of #4 or #5 rebar, spaced 12" on center, each way, centered in the slab and minimum 4,000 psi strength for durability.
 - e. All concrete surfaces shall be flat, broom finish or floated finish with chamfered or round edges.
4. Enclosures shall be secured to the concrete pad with a minimum of four (4) stainless steel wedge anchors.
5. Route remote monitoring antenna using a manufacturer supplied extension to the roof of the enclosure. Install the antenna lead wire through a water-proof opening or conduit on the side or top of the enclosure. Do not route antenna lead wire through any doors.

F. Test Stations:

1. Determine location of test stations based on actual site conditions and as approved by Owner or Designated Representative.
2. Locate test stations as depicted on Drawings and/or CP tables.

3. Locate all test stations in a protected location such as near fences, behind curbs, outside of roadways, and in areas that are accessible for personnel. Do not install test stations in open farm areas and that are restrictive to the property owner.
 - a. When routing test stations away from the protected pipe, all test station, anode, reference electrode, coupons, and other wires shall be installed in a minimum 1" diameter PVC conduit routed from the edge of the pipe trench to the test station location.
4. Post mount test stations are preferred if feasible. Install flush mount test stations in developed, paved, and landscape areas as determined based on field conditions and in accordance with the CP schedule. Place Carsonite marker with a CP test station label next to each flush mount test station.
5. Insulating Stone Installation
 - a. Remove topsoil to a uniform depth of approximately 6" in an area that extends at least in an 8ft square centered around test pedestals. Install crushed limestone a minimum depth of 6".
6. Make wire connections to test station terminal boards with crimp-on spade lug terminals.
7. Wire labeling:
 - a. Label and marking materials should be suitable for permanent identification-heat shrinkable marking sleeve.
 - b. Position markers in test stations so that they do not interfere with operation and maintenance.
 - c. Include pipe diameter and type, and wire function, as applicable.
 - d. Test station wires shall be color coded as shown on the drawings and specified herein and each wire shall be permanently identified using sleeves as shown on the drawings and specified herein. Heat shrink label onto each wire within 6" of termination. Replace any damaged or illegible labels during heat shrinking. Test station wiring shall have enough extra wire slack to extend a distance of two feet above the top of the test station box.

Examples:

42" STL	54" STL	32 lb	SRE	Coupon
W/L	W/L	Mag	CuCuS	10 cm ²
		Anode	O ₄	

G. Galvanic (Magnesium) Anodes:

1. Install anodes as shown on Drawings and/or CP tables.
2. Install anodes equally along each side of pipeline spaced 5 feet on center. Anodes should be placed a minimum of 2 feet or (1) pipe diameter (whichever is greater) below the invert of the pipe and maintain a minimum of distance of 3 feet from all other buried metallic structures.
3. Anodes should be placed horizontally or vertically at or below the invert of the pipeline.
4. Do not place anode in Engineered backfill (granular pipe embedment, gravel, squeegee, concrete, etc.). Install in native soils only.
5. Lowering of Anodes:
 - a. The Contractor will be responsible for inspecting anodes and lead wires for damage prior to installation. Damage to anodes or lead wires is cause for rejection of that anode assembly.
 - b. Maintain sufficient slack in the anode lead cables to prevent damage during installation and backfilling operations.
 - c. Lower anodes with rope sling or similar methods and do not lower using the anode lead wire.
 - d. During installation, if any anode is damaged or wire insulation is cut, gouged, or scraped, the anode and wire will not be acceptable.
 - e. No wire splices will be allowed except those shown on Drawings and approved by the Owner or Designated Representative.
 - f. Elevation and spacing of anodes shall be as shown on Drawings unless the Engineer modifies the anode depth and spacing in the field based on the drilling geological log and/or soil resistivity log.
6. Route anode wires along excavation to test station. Bury wires a minimum of 24 inches below grade or a minimum of 36 inches for agricultural areas.
7. Thoroughly compact native backfill a minimum of 1 foot deep above each anode.
8. Saturate the anode and backfill with approximately 5 gallons of clean water prior to completion of backfilling.

9. Obtain anode to soil measurements during backfill to confirm proper anode activation and function. If deficiencies are discovered, replace anode.
10. Install warning tape 12 inches above all anodes and other CP wires.

H. Stationary Reference Electrodes:

1. Install reference electrodes as shown on Drawings and/or CP tables.
2. Install reference electrodes a maximum of 6 inches from the structure under cathodic protection and/or 4 inches from any adjacent metallic coupons. Reference electrodes should be placed according to detail drawings at or below the springline of the pipeline but must not come into contact with the piping.
3. Lowering of Reference Electrodes:
 - a. The Contractor will be responsible for inspecting reference electrodes and lead wires for damage prior to installation. Damage to reference electrodes or lead wires is cause for rejection of that reference electrode assembly.
 - b. Maintain sufficient slack in the reference electrode lead cables to prevent damage during installation and backfilling operations.
 - c. Lower reference electrodes with rope sling or similar methods and do not lower using the reference electrode lead wire.
 - d. During installation, if any reference electrode is damaged or wire insulation is cut, gouged, or scraped, the reference electrode and wire will not be acceptable.
 - e. No wire splices will be allowed except those shown on Drawings and approved by the Owner or Designated Representative.
 - f. Elevation and spacing of reference electrodes shall be as shown on Drawings unless the Engineer modifies the electrode depth and spacing in the field based on the drilling geological log and/or soil resistivity log.
4. Route electrode wires along excavation to test station. Bury wires a minimum of 24 inches below grade or a minimum of 36 inches for agricultural areas.
5. Thoroughly compact native backfill a minimum of 1 foot deep above each electrode.
6. Saturate the electrode and backfill with approximately 5 gallons of clean water prior to completion of backfilling.

7. Obtain reference electrode to structure measurements during backfill to confirm proper electrode activation and function. If deficiencies are discovered, replace electrode.
8. Install warning tape 12 inches above all electrodes and wires.

I. Metallic Coupons:

1. Install metallic coupons as shown on Drawings and/or CP tables.
2. Install coupons a maximum of 6 inches from the structure under cathodic protection and/or 4 inches from any adjacent reference electrodes. Coupons should be placed according to detail drawings at or below the springline of the pipeline but must not come into contact with the piping.
3. Lowering of Metallic Coupons:
 - a. The Contractor will be responsible for inspecting metallic coupons and lead wires for damage prior to installation. Damage to coupons or lead wires is cause for rejection of that coupon assembly.
 - b. Maintain sufficient slack in the metallic coupon lead cables to prevent damage during installation and backfilling operations.
 - c. Lower metallic coupons with rope sling or similar methods and do not lower using the coupon lead wire.
 - d. During installation, if any metallic coupon is damaged or wire insulation is cut, gouged, or scraped, the metallic coupon and wire will not be acceptable.
 - e. No wire splices will be allowed except those shown on Drawings and approved by the Owner or Designated Representative.
 - f. Elevation and spacing of metallic coupons shall be as shown on Drawings unless the Engineer modifies the coupon depth and spacing in the field based on the drilling geological log and/or soil resistivity log.
4. Route coupon wires along excavation to test station. Bury wires a minimum of 24 inches below grade or a minimum of 36 inches for agricultural areas.
5. Thoroughly compact native backfill a minimum of 1 foot deep above each coupon.
6. Saturate the coupon and backfill with approximately 5 gallons of clean water prior to completion of backfilling.

7. Install warning tape 12 inches above all coupons and wires.

J. Wire Connections:

1. Use thermite weld method for electrical connection of copper wire to metallic surfaces. Follow manufacturer's procedures for installation. Assure that the pipe or fitting wall thickness is of sufficient thickness that thermite weld process will not damage the integrity of the pipe or fitting or protective lining. Hold back thermite welds from joints and/or flanges where gaskets may be damaged by the thermite weld heat.
2. For #10 AWG or smaller wires, install copper sleeves on wire ends prior to thermite welding.
3. After cooling, remove all weld slag and visually inspect wire connection. Remove and replace any defective connections.
4. Install Denso Protal 7125 repair coating over each completed connection. Repair exposed metal surfaces in accordance with coating manufacturer's recommendations.
5. Maintain a minimum of 6 inches of separation between any (2) thermite weld connections.
6. Attach test wires to pipe via exothermic weld and wrap wires around pipe for strain relief.

K. Buried Conductors:

1. Install test leads and negative leads to the pipeline and attach by thermite weld method to pipe.
2. Install negative leads from the pipe and route to the rectifier or negative junction box (if required) as shown on Drawings.
3. Identify all positive (anode) leads with red insulation or apply red electrical tape for identification purposes.
4. Bury cathodic protection cables and wires a minimum of 24 inches below finished grade.
5. Only splices shown on Drawings or approved by the Engineer are permitted on any wires, cables, or leads.
6. Insulation on wires shall be free of cut or abraded areas.

7. Avoid damage to existing structures, pipelines, and utilities during the trenching process.
 8. Cathodic protection cable trenches:
 - a. In a general location and route as shown on the Drawings.
 - b. Modify location to minimize possible damage to existing structures; obtain approval for modification.
 - c. Uniform depth and width, level, smooth, and free of any sharp objects.
 - d. Hand trenching may be required in some areas to avoid damage to existing structures.
- L. Warning Tape:
1. Bury approximately 12 inches above underground cathodic protection cable.
 2. Align parallel to and within 2 inches of centerline of conduit or cable run.
- M. Conductors in Boxes / Test Stations:
1. Do not damage wire, insulation, or conduit during the installation process.
 2. Route and maintain sufficient slack in cables to prevent the conductor from being unduly stressed, damaged, or broken during backfill operations.
 3. Do not exceed the cable manufacturer's recommendations for maximum pulling tensions and minimum bending radii.
 4. Where a pulling compound is used, use only a UL listed compound compatible with cable outer insulation and the conduit type involved.
 5. Wires:
 - a. Installed in continuous length, free of splices, except those approved by the Owner or Designated Representative.
 - b. Insulation: Free of cut, damaged, or abraded areas.
 - c. If field conditions dictate that a splice is required or wire is damaged, repair splices or damage to wire insulation at the discretion of the Owner or Designated Representative.
 - d. Replace wire and insulation with major damage.

- e. Splice and wire insulation repair must be approved.
6. Arrange wiring neatly in the rectifier, the test station, and the junction or terminal box; cut to proper length; remove surplus wire; and attach the terminal or connect to the junction box or the rectifier terminal as specified.
7. Install wire label tags on all wires indicating structure type and wire function (i.e. 48 lb anode, 48" waterline, 12" service outlet, etc.)
8. Provide cathodic protection cables, test station, and reference electrode wires with sufficient slack and looped or coiled at the pipeline and the boxes to prevent wire from being unduly stressed or broken during backfilling operations.

N. Joint / Continuity Bonding

1. All buried metallic pressure piping systems, which contain mechanical or non-welded joints, shall be made electrically continuous by bonding with AWG stranded copper wire. The bonding shall be achieved using the exothermic welding process with the bond wire size and quantity, per joint connection, in accordance with the following table:

Nominal Pipe Diameter	Wire Size	# of Wires Per Bond
12" or Less	#8 AWG	2
13" to 36"	#4 AWG	2
Greater than 36"	#2 AWG	3

2. Exothermic welding shall be used to attach wire type joint bonds to buried pipe and fittings.
3. Electrical continuity shall be provided on all underground metallic piping, valves and fittings and component parts thereof (except bolts) by bonding across every non-welded pipe joint (except for designated dielectric fittings).
4. Test each joint/continuity bonds as specified herein prior to backfill via Digital Low Resistance Ohm method and again after backfill using Calculated Resistance Measurement or similar.
5. All follower bonds to metallic fittings shall have a single #8 AWG joint bond wire attached as shown on the Drawings. Bonding must be done in a fashion to avoid shorting out mechanical insulating couplings and those with restraining rods.

6. Exothermic welding to narrow surfaces such as MJ follower gland rings shall be accomplished using mold sealing material temporarily placed around the base of the exothermic welder to minimize the leakage of molten weld metal.
7. Any MJ or flexible coupling follower gland rubber seals or any PVC pipe itself damaged by molten weld metal shall be replaced by and at the Contractor's sole expense.

O. Electrical Isolation

1. Accomplish electrical isolation using flange isolation kits, insulating mechanical couplings, di-electric fittings, or non-metallic piping where shown on the Drawings. All electrical and instrumentation, pipe supports, and other appurtenances should be configured to maintain proper electrical isolation at each insulating device location.

P. Concrete Encasement for Corrosion Control

1. Position the piping so that movement will not occur during concrete encasement.
2. Set wooden or earthen forms, stakes, tie-downs, and/or anchors prior to installation of concrete encasement.
3. Do not use rebar or allow any other metallic structure to come into contact with the encased metallic piping. Test and inspection each encased pipeline or fittings for electrical isolation prior to pouring concrete.
4. Install the required cathodic protection test leads, joint bonds, anodes, and other components as depicted on Drawings prior to pouring of concrete.
5. Pour concrete encasement in a continuous manner along the piping to avoid any seams or joints.
6. Ensure a 3" thick layer of concrete is placed around the piping and no voids, gaps, or un-encased portion of piping exists. The concrete shall be placed to provide direct, intimate contact with the bare embedded piping and fittings.
7. If piping contains insulating flanges or couplings, pour concrete to leading each of insulating device and overlap by 6 inches.
8. Test and inspection each encased pipeline or fittings for electrical isolation again after pouring of concrete
9. Allow concrete to properly cure prior to proceeding with backfilling operations

3.03. QUALITY CONTROL

- A. Installation is not complete until AC and DC wiring is complete and the rectifier and remote monitoring unit is capable of operating at the full rated capacity.
- B. Leave AC to the rectifiers off at all times and all rectifiers turned off at all times during the installation of cathodic protection groundbeds.
- C. Keep AC power, entrance switches, and rectifier enclosures secured with padlocks and safely turned off, until operation tests are performed by the Owner or Designated Representative.
- D. Preservation, restoration, and cleanup:
 - 1. Keep the site neat and orderly at all times.
 - 2. Remove excess equipment and cuttings daily when required by prevailing conditions.
 - 3. Contain and remove excess materials, mud, waste, products, and tailings.
 - 4. Confine operations to construction easements and work areas.
 - 5. Restore the site to a condition equivalent to the original condition to the satisfaction of the Owner or Designated Representative, jurisdiction, and the potential landowner(s).
 - 6. Prevent contamination of project area:
 - a. Do not dump or spill oil, fuel, solvents, coatings, rubbish, or similar materials on the ground or in or near streams or wetland areas.
 - b. Use caution to prevent stream or groundwater contamination.
 - c. Conform to federal, state, and local regulations.
 - d. Provide containment for and remove excess materials, drilling mud, and waste products from the project site as necessary to meet the local road and highway requirements and the permit and easement conditions.
 - e. Contain and cleanup contamination to any aquifer, stream, or soil at the Contractor's sole expense.
 - 7. Upon completion of Work, remove materials, scraps and debris from the premises and from the interior and exterior of devices and equipment.

8. Touch up scratches, scrapes, and chips in the interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency, and type of surface of the original finish.
9. If extensive damage is done to equipment paint surfaces, completely refinish to equal or better than factory finish.
10. Promptly correct damage to existing structures or utilities at the Contractor's sole expense.
11. Repair damage to concrete and asphalt sidewalks, curbs, roads, and driveways.
12. If subsequent trench or undercrossing settlement, cracking, subsidence, or other indication of failure occurs within the warranty period, promptly repair or replace at the Contractor's sole expense.

3.04. TESTS AND MEASUREMENTS

A. Electrical Isolation Testing

1. Piping which is electrically isolated for corrosion control purposes shall be tested prior to and after backfilling to verify electrical isolation from unintended structures.
 - a. Contractor's NACE CP Specialist (CP4) shall develop a test plan and submit to the Owner or Designated Representative for approval prior to completing any testing.
 - b. Acceptable test methods may include but not limited to:
 - (1) Induced current testing
 - (2) Flange Isolation Tester as per manufacturer's recommendations
 - (3) IR drop testing
 - (4) Remote 'Fixed Cell' testing
 - c. The pipeline shall be tested for electrical isolation at key elements to include but not limited to the following:
 - d. Transfer of Ownership locations.
 - e. Connections between dissimilar metals (i.e. welded steel to aluminum).
 - f. Cased segments of piping.

- g. Connections to electrically grounded components such as actuated valves, meters, pump stations, processing facility, and other structures.
 - h. Concrete encased segments of piping such building risers and valve vault penetrations.
- 2. Record Tests of each Electrical Isolation Component:
 - a. Description and location of pipeline and electrical isolation component under test.
 - b. Test method(s) utilized.
 - c. Date of test.
 - d. Summary of findings.
- 3. The Contractor shall assist the Owner or Designated Representative in the performance of such additional tests by providing electrical contacts and physical access to the pipe. This work, and any subsequent repairs and additional testing shall be performed at no additional cost to the Owner.

B. Joint Bond Electrical Continuity Testing

- 1. Piping which is electrically bonded for corrosion control purposes shall be tested prior to and after backfilling to verify electrical continuity.
- 2. Pressure piping requiring such testing shall be piping which has mechanical or non-welded joints.
- 3. Electrical resistance of the pipe shall be measured in sections for resistance of the pipe shall be measured in sections for which the total length of pipe and the number of mechanical joints is known.
- 4. The test station wires shall be used as the electrical contact points to the pipe for such measurements to facilitate repeating such measurements subsequent to backfilling.
- 5. The electrical resistance obtained shall be compared with the calculated resistance for each section of piping. The calculated resistance shall be based on the resistance per unit length of pipe. Such resistance shall be a function of the resistivity and the cross-sectional area of the metal conductor in the pipe wall, the length of pipe, the number of pipe joints, the resistance of the bond wires installed across the pipe joints, and the number of bond wires within the pipe length being measured.

6. Measured resistance greater than 120 percent of the corresponding calculated resistance shall be reviewed and additional tests shall be made to determine the reason for the variation and the corrective measures required.
7. The Contractor shall assist the Owner or Designated Representative in the performance of such additional tests by providing electrical contacts and physical access to the pipe. This work, and any subsequent repairs and additional testing shall be performed at no additional cost to the Owner.
8. The acceptable resistance value obtained prior to backfill shall be used as the standard for comparison for the resistance values subsequent to backfilling.
9. Joint Bond Resistance Test
 - a. General:
 - (1) The Contractor shall test completed joint bonds for electrical continuity using a digital low resistance ohmmeter (DLRO).
 - (2) Joint bond quality control test shall be performed on all bonded joints after the bonds are installed but before backfilling.
 - (3) Furnish all equipment and materials as required for test.
 - b. Digital Low Resistance Ohmmeter Test Method:
 - (1) Required Equipment and Materials:
 - (a) One Biddle Model 247001 digital low resistance ohmmeter (or equal).
 - (b) One set of duplex helical current and potential handspikes, Biddle Model No. 241001, cable length as required.
 - (2) Test Procedure:
 - (a) Measure the resistance of joint bonds with the low resistance ohmmeter in accordance with the manufacturer's written instructions.
 - (b) Use the helical handspikes to contact the pipe on each side of the joint without touching the thermite weld or the bond. The contact area shall be cleaned to bright metal by filing or grinding and without any surface rusting or oxidation.

- (c) Record the measured joint bond resistance on the test form described herein.
- (d) Repair any damaged pipe coating in accordance with these specifications.

(3) Joint Bond Acceptance

- (a) Joint bond resistance shall be less than or equal to the maximum allowable bond resistance values shown below.

Bond Wire Length	Bond Wire Size	Maximum Allowable Resistance (μ -ohms)		
		One Bond Wire Per Joint	Two Bond Wires Per Joints	Three Bond Wires Per Joint
12"	#8	870	435	290
18"	#8	1304	652	435
24"	#8	1740	870	580
30"	#8	2174	1087	725
36"	#8	2610	1305	870
12"	#4	518	259	172
18"	#4	776	388	259
24"	#4	1035	518	346
30"	#4	1294	647	432
36"	#4	1554	777	518
12"	#2	325	162	108
18"	#2	486	243	162
24"	#2	648	324	216
30"	#2	810	405	270
36"	#2	972	486	324

- (b) The Contractor shall remove and replace all joint bonds on a joint that exceeds the maximum allowable resistance. Replacement joint bonds shall be retested for compliance with the specified bond resistance.

c. Record Tests of Each Bonded Pipeline:

- (1) Description and location of pipeline under test;

- (2) Starting location and direction of test;
- (3) Date of test;
- (4) Joint type; and
- (5) Measured joint bond resistance using specified DLRO meter.

d. Testing After Backfill (Calculated Resistance Method or similar)

- (1) The pipeline shall be tested for electrical continuity along its entire length using the calculated resistance method or similar test plan developed under the direction of the Contractor's NACE CP Specialist (CP4). The test plan shall be submitted to the Owner or Designated Representative for approval prior to completing any testing.
- (2) If calculated resistance method is utilized:
 - (a) Apply suitable current (minimum 15 amps) along segments not to exceed 2,000 feet.
 - (b) Electrical resistance of the pipe shall be measured in sections for resistance of the pipe in sections for which the total length of pipe and the number of mechanical joints is known.
 - (c) The test station wires shall be used as the electrical contact points to the pipe for such measurements to facilitate repeating such measurements subsequent to backfilling.
 - (d) The electrical resistance obtained shall be compared with the calculated resistance for each section of piping. The calculated resistance shall be based on the resistance per unit length of pipe. Such resistance shall be a function of the resistivity and the cross sectional area of the metal conductor in the pipe wall, the length of pipe, the number of pipe joints, the resistance of the bond wires installed across the pipe joints, and the number of bond wires within the pipe length being measured.
 - (e) Measured resistance greater than 120 percent of the corresponding calculated resistance shall be reviewed and additional tests shall be made to determine the reason for the variation and the corrective measures required.
- (3) Record Tests of Each Bonded Pipeline:

- (a) Utilize the form provided in the CP Testing Plan.
 - (b) Description and location of pipeline under test.
 - (c) Starting location and direction of test.
 - (d) Date of test.
 - (e) Joint type and summary of calculated resistances.
 - (f) Measured joint bond resistance.
 - (g) Results, observations, and comments.
- (4) The Contractor shall assist the Owner or Designated Representative in the performance of such additional tests by providing electrical contacts and physical access to the pipe. This work, and any subsequent repairs and additional testing shall be performed at no additional cost to the Owner.

C. CP Commissioning and Testing:

1. Prior to Initial Acceptance, notify the Owner or Designated Representative and provide a minimum of 2 weeks' notice that the installation is ready to be turned on.
2. Provide a cathodic protection commissioning and testing plan to the Owner or Designated Representative for review and approval.
3. Functional and Final Testing to be overseen or performed by the Contractor's NACE CP Specialist (CP4).
4. Energize installation as per the approved testing plan.
5. Operating Test: Conduct a series of tests to demonstrate that equipment and material are installed correctly and operating properly for initial approval.
 - a. Locate, correct, and retest system defects or incomplete work identified during functional and final testing or warranty inspections at no additional cost to the Owner.
 - b. Functional testing (to be completed upon completion of pipeline construction):
 - (1) Commission all CP devices and measure native and polarized structure-to-soil potential of pipeline at each test station and cathodic protection device using applicable equipment. Include all

test stations, isolation devices, bonded segments, above grade appurtenances, surrounding metallic structures, and other identified locations.

- c. Final Testing (to be completed 30 days after functional testing and/or connections of all CP devices)
 - (1) Make adjustments in the output of the system; conduct sufficient testing throughout the network of protected structures and piping to ensure proper installation and cathodic protection levels.
 - (2) Locate, correct, and retest system defects or incomplete work identified.
 - (3) Warranty Testing (to be completed 30 days prior to end of warranty period or approximately 1 year after installation).
 - (4) Make adjustments in the output of the system; conduct sufficient testing throughout the network of protected structures and piping to ensure proper installation and cathodic protection levels.
 - (5) Locate, correct, and retest system defects or incomplete work identified.
- 6. The Contractor shall assist the Owner or Designated Representative in the performance of such additional tests by providing electrical contacts and physical access to the pipe. This work, and any subsequent repairs and additional testing shall be performed at no additional cost to the Owner.
- 7. Provide a final chronological installation and testing report.
 - a. Include:
 - (1) NACE certifications of Contractor's NACE CP Specialist (CP4).
 - (2) Tabulated reports of the following:
 - (a) Drilling/excavation log.
 - (b) Soil resistance log.
 - (c) Backfilled anode resistance log test results.
 - (d) Final anode placement, coke breeze, casing, and seal depths
 - (e) Final anode current measurements

- (f) Native and polarized CP potential measurements
 - (g) Insulated flanges / fittings testing with test methods indicated
 - (h) Electrical continuity testing results
 - (i) Reference electrode and coupon testing results
 - (j) All reports shall contain both stationary reference electrode readings and portable reference electrode readings.
- (3) Changes, modifications, and alterations from plans.
 - (4) Comments relative to the Project.
 - (5) Failures, defects, and any repairs.
 - (6) Retesting information.
 - (7) Recommendations.
- b. As-Built Records and Documentation:
 - (1) As-Built records shall annotate all CP components and include the following as a minimum:
 - (a) Drawings showing location of each test station, reference electrode, anode, and insulated flanges / fittings
 - c. Report should be signed and sealed by the Contractor's NACE CP Specialist (CP4) and submitted for approval by the Owner or Designated Representative.

3.05. CATHODIC PROTECTION CRITERIA

- A. Cathodic protection level shall be considered satisfactory when all pipe-to-soil potential measurements met the -850 mV criteria set forth in NACE SP0169. IR drops in the soil, coating, and measurement circuit shall be compensated for in the measurements.
- B. All "Native State" anode-to-soil potential measurements must be shall be 1.5 volts or more negative.
- C. Piping with native potential measurements of -0.4 volts or more positive shall be investigated for improper electrical isolation and/or interference.

3.06. INADEQUATE PROTECTION

- A. Inadequate pipe joint continuity and/or cathodic protection levels due to defective or incorrect installation work shall be corrected by and at the sole expense of the Contractor.
- B. Any anode with a "Native State" anode-to-soil potential less than the specified -
- C. 1.5 volts (CSE) shall be replaced by and at the sole expense of the Contractor, as required by the Owner or Designated Representative.

3.07. TRACER WIRE TESTING

- A. See Section 33 05 26: Utility Identification.

3.08. OPERATION AND MAINTENANCE MANUAL

- A. The Contractor's NACE CP Specialist (CP4) shall prepare and furnish a written Operations and Maintenance (O&M) manual upon completion of the cathodic protection system testing. The O&M manual shall contain the following minimum information:
 - 1. Physical description of the protected pipeline including diameter, pipe material, type of pipe joint construction, length, and type of external coating system.
 - 2. Cathodic protection system description including anode sizes and locations, test station locations, and locations and type of electrical isolation fittings.
 - 3. Schematic drawing (11" x 17" size) of the pipeline showing locations of cathodic protection system test stations and electrical isolation fittings. The Drawing shall also include the approximate alignment of the pipeline, connections to existing piping, and key topographic information such as roads and ditches. The actual locations of the test stations installed out of the roadways should be shown. The Drawing does not have to be drawn to scale.
 - 4. Final cathodic protection test data.
 - 5. Operations and maintenance procedures and manufacturer manuals or data outlining the routine steps required to operate and maintain the cathodic protection system and components.
 - 6. Provide two (2) complete training sessions to City of Thornton personnel for the Cathodic Protection systems, operations and maintenance. Provide electronic copies of all manuals in .PDF file format. Provide 5-year license for all required software.

3.09. SPECIAL WARRANTY

- A. Warranty for the cathodic protection systems and installations shall be for a period of 5 years from the date of Substantial Completion. Refer to the General Conditions and Special Conditions for additional requirements.

END OF SECTION

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SECTION 26 42 16

CLOSE INTERVAL SURVEY

PART 1 - GENERAL

1.01. SUMMARY

A. Section Includes:

1. Materials and requirements to perform close interval surveys (CIS) of buried, metallic pipelines.
2. Contractor shall furnish all necessary labor, supervision, equipment, tools, and material to perform each CIS as described herein.

1.02. REFERENCES

A. The latest revision of the following minimum standards shall apply to the materials and installation included in this Specification. In case of conflict, the most stringent requirements shall apply:

1. National Association of Corrosion Engineers International (NACE):
 - a. Standard Practice SP0169 – Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
 - b. Standard Practice – SP0286 – Electrical Isolation of Cathodically Protected Pipelines.
 - c. Standard Practice – SP0207 – Performing Close-Interval Potential Surveys and DC Surface Potential Gradient Surveys on Buried or Submerged Metallic Pipelines.
 - d. Test Method – TM0497 – Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems.

1.03. DEFINITIONS

- ###### A. 'AC' Survey: 'ON' Survey: Collection of data regarding the AC pipe-to-soil potential measurements along a given pipe span.

- B. Cathodic Protection: The electrical method of reducing or eliminating corrosion by making previous anodic areas on the structure surface a cathode by creating a DC current flow to the structure by use of a cathodic protection system.
- C. Cathodic Protection Criteria: Conform to NACE SP0169.
- D. Cathodic Protection Systems:
 - 1. Galvanic anode system: Galvanic anode material, usually magnesium or zinc, which naturally corrodes or sacrifices itself and does not require an outside power source.
 - 2. Impressed current system: Utilizes an outside power source, usually a rectifier (that converts AC to DC current), and forces (impresses) current from a number of anodes (or groundbed) through the environment to the structure to be protected.
- E. Cathodic Protection Station (CPS): An impressed current cathodic protection installation location consisting of rectifier, groundbed, and anode terminal box.
- F. Current Interrupter: A portable or permanent electrical switching device capable of providing GPS synchronized interruption of cathodic protection rectifiers (Owner and Foreign), bonds, and other sources of current.
- G. Deep Borehole Anode Groundbed
 - 1. Cathodic protection impressed current groundbed that is installed in a drilled hole at a prescribed depth from the structure being cathodic protected to achieve electrical remoteness.
 - 2. Typically, anodes and coke breeze are installed in the lower portion (active column) and high resistant or sealing material is installed in the top section of the drilled hole (inactive column).
- H. Electrically Continuous Pipeline: Linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this Section.
- I. Electrical Isolation: The condition of being electrically isolated from other metallic structures and the environment as defined in NACE SP0286.

- J. Ferrous or Metallic Pipe: Pipe or structure made of steel or iron alloys and pipe or structure containing steel or iron as a principal structural material (such as steel, ductile iron, and cast iron).
- K. Foreign-Owned: Buried pipe or cable not specifically owned or operated by the Client.
- L. Influence Currents: Currents that can cause distortion of the pipe-to-soil potential readings and interpretation which could result in insufficient cathodic protection.
- M. Interference Currents: Currents that can initiate or accelerate corrosion and will always include areas of current pick-up and discharge.
- N. Lead, Lead Wires, Joint Bond, and Cable: Insulated copper conductor; the same as wire.
- O. 'ON' Survey: Collection of data without cycling of cathodic protection rectifiers (Owner and Foreign), bonds, or other sources of current.
- P. 'ON/OFF' Interrupted Survey: Also known as a polarized or instant-off survey. Collection of data involving cycling of cathodic protection rectifiers (Owner and Foreign), bonds, and other sources of current.
- Q. 'ON/OFF' I&I Survey: Also known as an interference and/or influence (I&I) survey. Collection of data involving cycling of cathodic protection rectifiers (Owner only, Foreign rectifier left on), bonds, and other sources of current.
- R. Pipe-to-Soil Potential: Also known as Structure-to-Reference Electrode Potential or Pipe-to-Electrolyte Potential: The difference in voltage (potential) between the subject metallic structure and the electrolyte in which it is buried or submerged, as measured to the standard specified reference electrode placed in contact with the electrolyte.
- S. 'STATIC' Survey: Also known as a native, depolarized, or free-corrosion potential survey. Collection of data involving turning off or de-energizing all sources of cathodic protection current (Owner and Foreign) to record the free-corrosion pipe-to-soil potentials.

1.04. SYSTEM DESCRIPTION

- A. Survey Requirements: Materials and equipment shall be new and the manufacturer's latest certificate of compliance (within 1 year) shall be provided.
- B. Performance Requirements:

1. Show evidence of proper interruption and de-energization of all sources of current (Owner and Foreign).
2. Obtain quality data by properly saturating the electrolyte and moving at a pace that produces accurate readings.

1.05. SUBMITTALS

A. Submittals for Review:

1. Product data:
 - a. Manufacturer's catalog cuts for all materials.
 - b. Include manufacturer's name and provide sufficient information to show that materials meet the requirements of the project.
2. Quality Control:
 - a. Contractor's Cathodic Protection Specialist (CP4) shall oversee the survey work including but not limited to, identification of potential sources of current (Owner and Foreign), installation of current interrupters, monitoring of survey crews, review of all captured data, wave forms (plots), interruption cycles, field conditions, foreign crossings, cased segments, electrical isolation device locations to ensure they are accurately assessed and tested.
3. NACE qualifications of Contractor personnel.
4. Testing Plans and Procedures
 - a. All testing plans and procedures shall be in accordance with the requirements herein and prepared by the Contractor's Cathodic Protection Specialist (CP4).
5. Final reporting and documentation, including:
 - a. A Findings and Recommendations report of all captured data signed and stamped by the Contractor's Cathodic Protection Specialist (CP4).
 - b. Summary of survey segments to include dates/times, daily weather conditions, start/stop stationing, direction of survey, ROW conditions and

terrain, confirmation that water was applied to ROW, and any notes/comments such as access or landowner issues.

- c. Summary of the identification and output of any influencing rectifiers (Owner and Foreign), bonds, and other sources of current and GPS coordinates.
- d. Summary of daily interruption cycles along with start of day, mid-day, and end of day wave forms (plots).
- e. Summary of location and plots of any dataloggers installed to confirm proper polarization or de-polarization of the piping or to measure any other AC or DC currents.
- f. Final, color copies of all pipe-to-soil potential plots.
- g. Excel spreadsheet of all captured data to include pipeline name, GPS coordinates, date/time, potential measurements, notes/comments, stationing (both CIS stationing and correlated alignment stationing) of all readings and above grade reference points (roads, valves, streams, test stations, fences, ditches, powerlines, etc.).

1.06. QUALITY ASSURANCE

A. Contractor's Qualifications:

- 1. A minimum of 10 years of experience of close interval surveys and corrosion control testing of comparable size and complexity.
- 2. Five comparable projects completed in the last 5 years for review and approval.

B. Cathodic Protection Specialist Qualifications:

- 1. Currently certified by NACE as a Cathodic Protection Specialist (CP4).
- 2. Perform field observation and oversee testing services during each survey associated with the project.
- 3. Complete all data analysis and evaluation and provide a final findings and recommendations report.

C. Manufacturer's Qualifications:

1. Regularly engaged on a full-time basis in the manufacture of products in this Section for a minimum of 5 years.
2. Provide certification that all materials and components meet the requirements of Drawings and Specifications; include references for the applicable section of the Specifications and applicable standard details.

D. Field Supervision:

1. Provide a superintendent or foreman to supervise the survey site. Personnel to remain on-site at all times.
2. Currently certified by NACE as a Cathodic Protection Technician (CP 2) or higher.
3. Minimum of (3) years of experience in corrosion control.

1.07. DELIVERY, STORAGE AND HANDLING

A. Cathodic Protection Materials

1. Store off the ground.
2. Protect against weather, condensation, and mechanical damage.
3. Handle with care.
4. Do not sharply bend or tightly coil the wire.
5. Replace equipment or materials damaged in shipment or installation.

B. Reference Electrodes:

1. Do not allow to freeze.
2. Store in a protected area.
3. Calibrate daily.

PART 2 - PRODUCTS

2.01. MANUFACTURERS

- A. Use of the manufacturer's name and model or catalog number is for the purpose of establishing a standard of quality and the general configuration desired.
- B. Substitutions: As approved by Engineer if considered equal.

2.02. SUPPLIERS

- A. Supplier: Farwest Corrosion, Denver, CO or MESA Products, Denver, CO
- B. Submit alternate suppliers for approval.

2.03. MATERIALS

- A. Portable Reference Electrodes:
 - 1. Copper / Copper Sulfate.
 - a. List the manufacturer's name, model number, year manufactured, serial number, and calibration results.
- B. CIS Field Computer: American Innovations, MC Miller, or similar models.
- C. Dataloggers: CorTalk GPS synchronized data logger or similar.
- D. Current Interrupter:
 - 1. GPS synchronized switching device.
 - a. List the manufacturer's name, model number, year manufactured, serial number, and calibration results.
- E. Wire:
 - 1. MicroMax #30 AWG solid wire with single-build polyurethane/nylon overcoat.
 - 2. Length as required.

PART 3 - EXECUTION

3.01. GENERAL

- A. Complete survey operations during daylight conditions.
- B. All equipment, instruments, and accessories furnished by the Contractor must be in satisfactory operating condition and be made available for the Owner or Designated Representative for inspection during the survey.
- C. Note weather conditions and ROW conditions on daily survey logs.
- D. All survey wire must be retrieved daily or immediately after completion of each survey. No wire will be allowed to be left overnight along the ROW.
- E. All temporary markings, flagging, and other designations must be removed at the conclusion of each survey or as requested per the landowner.
- F. Contractor is responsible for notifying and coordinating access with landowner and/or other stakeholders. This includes scheduling work to minimize crop damages, livestock disturbance, on-going construction activities, and other ROW constraints.
- G. Minimize disturbance to each ROW and avoid driving in muddy or snowy conditions. All-terrain and side-by-side quad vehicles may be used but are not permitted on any agricultural tracts or land that are being prepared for planting.

3.02. PREPARATION FOR SURVEYS

- A. The Owner or Designated Representative CP Specialist has the option of which survey type, 'ON/OFF' I&I, ON/OFF Interrupted, STATIC', or 'AC' to complete. Depending on the results of each individual survey, additional surveys may or may not be required.
- B. The Contractor is responsible for notifying the Owner or Designated Representative, all landowner, and/or stakeholders along the project ROW of pending survey activities. Coordination shall include proposed survey dates/times, livestock or crop issues, access issues, and coordination with foreign CP system operators.
- C. The Contractor shall canvass the subject pipeline region to determine possible influencing/interfering rectifiers (Owner and Foreign), bonds, or other current sources within a 2-mile radius of the pipeline ROW. Up to a 10-mile radius may be required if a

foreign pipeline crosses the subject ROW and is considered a historical interference threat.

1. If possible, obtain the following relevant information:
 - a. Relationship to project pipeline (parallel, crossing, etc.)
 - b. Operator identification and contact information
 - c. GPS Coordinates
 - d. Rectifier or current source output
 - e. Type of CP system and layout
- D. Surveys shall be conducted in such a manner so as to allow data to be overlapped onto single visual plots for comparison of data between the 'OFF', 'ON/OFF', and 'AC' surveys.
- E. 'ON/OFF' I&I Survey Preparation:
 1. Rectifiers and other current sources (Owner and Foreign) shall be energized to polarize the pipeline. Dataloggers shall be installed at key locations and data analyzed during the polarization period to confirm proper polarization.
 2. After a minimum of 30 days of polarization, each rectifier (Owner only), bond, or other identified current source should be synchronously interrupted on a cycle of 80% 'ON' and 20% 'OFF' (1.6 seconds on, 0.4 second off). All foreign CP system shall be left 'ON' during the course of the survey.
 3. Extended period dataloggers shall be installed at key locations and data analyzed during the survey to confirm proper interruption synchronization and current variations.
- F. 'ON/OFF' Interrupted Survey Preparation:
 1. Rectifiers and other current sources (Owner and Foreign) shall be energized to polarize the pipeline. Dataloggers shall be installed at key locations and data analyzed during the polarization period to confirm proper polarization.

2. After a minimum of 30 days of polarization, each rectifier (Owner and Foreign), bond, or other identified current source should be synchronously interrupted on a cycle of 80% 'ON' and 20% 'OFF' (1.6 seconds on, 0.4 second off).
3. Extended period dataloggers shall be installed at key locations and data analyzed during the survey to confirm proper interruption synchronization and current variations.

G. 'OFF' Survey Preparation:

1. Rectifiers (Owner and Foreign), bonds, and other current sources shall be de-energized and/or disconnected to allow for de-polarization the pipeline. Dataloggers shall be installed at key locations and data analyzed during the de-polarization period to confirm proper de-polarization.
2. All structures shall be allowed to de-polarize for no less than 5 days before completing any 'OFF' survey. Reversal of the rectifier or current source cables to speed up the depolarization process is not allowed.

H. 'AC' Survey Preparation:

1. The Contractor shall notify the AC powerline operator to determine the magnitude and date/times of peak AC loads. Surveys should be coordinated to occur during these peak times.
2. Dataloggers shall be installed at key locations and data analyzed to confirm magnitude and peak AC load times.

I. Watering:

1. Watering of each project ROW may be required depending on current ROW conditions and weather. To prove watering is not required, in-situ and saturated pipe-to-soil potentials shall be taken prior to the start of the survey day.
 - a. If the in-situ pipe-to-soil potential varies from the saturated pipe-to-soil potential by more than 5%, watering of the project ROW shall be required before and during surveying.
 - b. If deviation is less than 5%, watering is not required.

- c. If watering is not performed, in-situ and saturated pipe-to-soil potentials must be completed every 2 hours through the survey day and recorded on the daily run summary log.

3.03. SURVEYING

- A. The survey shall be performed in the direction of flow, from test location to test location. If reverse surveys are required due to ROW constraints, the data shall be properly reversed but the original direction of the survey shall be noted on the final plots and daily run summary logs.
- B. The project pipeline shall be properly located, staked, and flagged at 100 foot intervals.
- C. Pipeline location, Depth of Cover (DOC), and GPS sub-meter mapping shall be performed in conjunction with each CIS for purposes of aligning data footages to within +/- 5 foot. DOC and GPS measurements shall be recorded at 100 foot intervals.
- D. Record all pipeline features and above grade reference points (roads, valves, appurtenances, streams, test stations, fences, ditches, powerlines, etc.). Include GPS coordinates.
- E. Reference electrodes shall be calibrated and/or cleaned before the start of each survey day and the readings records on the daily run summary logs. A test reference electrode shall be maintained by each survey crew and calibrations shall be equal to or less than 5mV.
- F. Field computers shall be set to collect CIS data in the CPS-sync mode (not a HI/LO or MIN/MAX mode) so as not to misinterpret 'flipped/inverted' readings.
- G. For interrupted surveys, obtain daily wave forms (plots) at 3 intervals (start of day, mid-day, and end of day) to verify interrupter synchronization, as well as any area of suspected interference or 'inverted' potentials.
- H. Continuous logging of GPS coordinates (WGS 84) and footages shall be accomplished during each survey.
- I. Manual or automatic triggers may be used for recording of pipe-to-soil data. Manual triggering may be required if automatic trigger data is deemed inaccurate by Owner or Designated Representative.

- J. All pipe-to-soil potentials shall be taken in 3 to 5 foot intervals unless otherwise approved.
- K. Re-connection at every available test location (test station, valve vault, appurtenance, etc.) shall be accomplished.
- L. AC pipe-to-soil potential measurements shall be recorded at each re-connect as well as at areas susceptible to AC interference such as physical transitions of the pipeline within 500 feet of any High Voltage AC (HVAC) corridors.
- M. At every re-connect, an ON/OFF lateral (left and right) potential measurement shall be recorded as applicable.
- N. At every re-connect, an ON/OFF near and far ground potential and an ON/OFF metal IR drop measurement shall be recorded as applicable.
- O. The IR drop due to the piping shall be determined for each survey section (from test location to test location) and recorded in the datalogger. Determination of the IR drop shall include both the 'ON' and 'OFF' readings as applicable. The 'OFF' IR reading should be close to zero or no greater than 20mV. If the IR drop is more than 20mV, the rectifiers current interruption cycles may be considered unsynchronized and immediate corrections shall be made and the affected test span re-surveyed at no cost to Owner.
- P. ON/OFF potential measurements of both the Owner and Foreign piping shall be obtained at all foreign crossings with available test leads. This includes bond currents (critical, non-critical, and continuity) as well as electrical isolation devices connected to the mainline at each tap, lateral, or other piping connection.
- Q. A minimum of 10 'OFF' readings shall be obtained every 100 feet as applicable depending on the survey type.
- R. Creek/river/wetland crossings, paved areas, or other sections of piping where contact with soil (electrolyte) is not possible or presences a significant risk to survey personnel may be skipped. The skipped sections should be limited to the fullest extent possible and properly documented on the daily run summary logs.
- S. Daily field plots of survey data shall be provided to the Owner or Designated Representative for review within 24 hours. Any unacceptable surveys shall be completed again the following day at no cost to Owner.

1. A daily run summary log listing the pipeline name, date, start/stop times, type of survey, start/stop CIS stationing, interruption cycles and items, survey direction, weather conditions, ROW conditions, watering requirements and test results, reference electrode calibrations, skipped sections of piping, and other requested information shall be included along with the daily field plots.

3.04. FIELD QUALITY CONTROL

- A. Record each rectifier, bond, and current source output prior to beginning each survey. Return each rectifier, bond, and current source to its original, as-found condition upon conclusion of each survey.
- B. Notify Owner or Designated Representative, or Owner CP Specialist , and Foreign operators of any modification or temporary installation of current interrupters. Include anticipated dates/times and field point of contact.
- C. Maintain security of all rectifiers and current sources at all times during survey. Do not leave rectifier cabinets open and unsecured.

3.05. DATA ANALYSIS AND DOCUMENTATION

A. Data Analysis:

1. Contractor's Cathodic Protection Specialist (CP4) shall analyze and review all survey data and providing the following minimal items within the analysis:
 - a. Tabular listing of areas not meeting the NACE criteria (-850mV and/or 100 mV) for cathodic protection.
 - b. Possible anomaly areas due to coating defects, stray currents, electrical shorts, failing electrical isolation devices, or other issues.
 - c. Recommendations for any suspected anomaly or interference mitigation as well as any possible upgrades to the existing CP system(s).
 - d. Recommendations for any additional or future testing.
2. All findings and recommendations shall be derived from the raw data collected in the field. No computer 'smoothing' or modification of the data will be accepted.

B. Final Report:

1. Equipment calibrations and certifications.
2. NACE qualifications and certifications of all survey personnel and Contractor's Cathodic Protection Specialist (CP4).
3. Daily run summary logs that include the following:
 - a. Pipeline name
 - b. Date of Survey
 - c. Type of Survey
 - d. Direction of Survey
 - e. Start / Stop Times
 - f. Start / Stop CIS Stationing
 - g. Weather Conditions
 - h. ROW Conditions
 - i. Reference Electrode Calibrations
 - j. Watering Requirements and Bi-Hourly Test Results
 - k. Interruption Cycles and Items Interrupted
 - l. Wave forms (plots) for any interrupted surveys
 - m. Start / stop stationing of any skipped areas of piping and reason for not surveying (wetland, road crossing, etc.).
 - n. Notes/Comments on landowner/access issues, survey issues, etc.
4. Interruption summary with pre-survey current outputs and post-survey outputs of any influencing rectifiers (Owner and Foreign), bonds, and other sources of current. Include GPS coordinates, Owner information, and point of contact.
5. Data logging results

- a. Summary of location, GPS coordinates and plots of any dataloggers installed to confirm proper polarization, de-polarization, AC potentials, DC potentials, and/or current synchronization.
6. Final color, copies of all pipe-to-soil potential plots shall be on 8 ½ x 11 paper with separate plots for each pipeline surveyed.
 - a. Surveys may be combined onto single plots (i.e. ON/OFF and STATIC) as long as data is readable and comprehensible.
 - b. Include the NACE -850mV and/or 100 mV criteria line on all plots as applicable
 - c. Minimum scales for graphing the data shall be 1" equals 100 feet for stationing (X-axis) and scale as-needed for the pipe-to-soil potential measurements (Y-axis).
 - d. Indicate the survey direction of each individual survey on each plot.
 - e. Include skipped sections of piping on each plot.
 - f. Include stationing numbers and applicable notes/comments.
7. Google Earth KMZ or KML files of all surveyed pipelines with GPS coordinates and stationing. The Google Earth files shall be delineated as follows:
 - a. Mark all piping sections that meet or exceed the NACE -850mV criteria as green.
 - b. Mark all piping sections that meet or exceed the NACE 100mV criteria but not the -850mV criteria as yellow.
 - c. Mark all piping sections that do not meet with the NACE -850mV or the 100mV criteria as red.
 - d. Include any applicable notes or comments on anomalies, issues, ROW conditions, field notes, or other items.
8. Excel Spreadsheet of all raw data and analyzed data for each survey. The following minimum data should be included:
 - a. Pipeline Name

- b. CIS stationing
 - c. Alignment stationing
 - d. Distance between readings
 - e. Sub-meter GPS coordinates (WGS 84)
 - f. Start and stop stationing of any skips or non-surveyed segments of piping and reason for not surveying
 - g. AC potential measurements
 - h. Foreign piping measurements and electrical isolation testing measurements.
 - i. Near and Far Ground measurements
 - j. IR readings for each test span
 - k. 'ON', 'OFF', and 'STATIC' measurements as applicable
 - l. Depth of Cover measurements
 - m. Pipeline features and above grade reference points (roads, valves, streams, test stations, fences, ditches, powerlines, etc.).
9. Report should be signed and sealed by the Contractor's Cathodic Protection Specialist (CP4) and submitted electronically for approval by the Owner or Designated Representative.

END OF SECTION

SECTION 26 42 20

AC MITIGATION FOR UNDERGROUND AND SUBMERGED PIPING

PART 1 - GENERAL

1.01. SUMMARY

A. Section Includes:

1. Materials and requirements to provide AC mitigation (grounding) and monitoring at above grade appurtenances collocated within High Voltage Alternating Current (HVAC) corridors.

1.02. REFERENCES

A. The latest revision of the following minimum standards shall apply to the materials and installation included in this Specification. In case of conflict, the most stringent requirements shall apply:

1. National Association of Corrosion Engineers International (NACE):
 - a. Standard Practice – SP0169 - Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
 - b. Standard Practice – SP0286 – Electrical Isolation of Cathodically Protected Pipelines.
 - c. Standard Practice – SP0177 – Mitigation of Alternating Current and Lightning Effects on Metallic Structures and Corrosion Control Systems
 - d. Standard Practice – SP21424 – Alternating Current Corrosion on Cathodically Protected Pipelines: Risk Assessment, Mitigation, and Monitoring.

1.03. DEFINITIONS

- A. AC: Alternating current generated by distribution or transmission power systems.
- B. AC Induction: Alternating voltages and currents induced on a structure because of proximity to overhead AC power system.

- C. 'AC' Survey: 'ON' Survey: Collection of data regarding the AC pipe-to-soil potential measurements along a given pipe span.
- D. AC Mitigation Criteria: Conform to NACE SP0177 and SP21424
- E. AC Mitigation System (ACM):
 - 1. Series of low structure-to-ground electrodes (normally anodes or similar), solid state decouplers, gradient control mats, and other components used to dissipate AC current accumulating on a structure due to the presence of nearby AC powerlines
- F. Bond: A low-impedance connection (usually metallic) provided for electrical continuity.
- G. Cathodic Protection: The electrical method of reducing or eliminating corrosion by making previous anodic areas on the structure surface a cathode by creating a DC current flow to the structure by use of an external anodic structure.
- H. Dead-Front Construction: A type of construction in which the energized components are recessed or covered to preclude the possibility of accidental contact with elements having electrical potential.
- I. Decoupler: An electrical device that permits the passage of AC current but blocks the passage of DC current.
- J. Electrical Isolation: The condition of being electrically isolated from other metallic structures and the environment as defined in NACE SP0286.
- K. Ferrous or Metallic Pipe: Pipe or structure made of steel or iron alloys and pipe or structure containing steel or iron as a principal structural material (such as steel, ductile iron, and cast iron).
- L. Foreign-Owned: Pipe, utility, or structure not specifically owned or operated by the Client.
- M. Functional and Performance Testing:
 - 1. Testing that is necessary to demonstrate that the installed equipment and systems function as specified and operate in the manner intended.
 - 2. Functional testing is a prerequisite to performance testing for equipment and systems that are specified to have a performance test.

- N. Gradient Control Mat: A system of bare conductors connected to the affected structure and placed on or below the surface of the earth, usually at above grade or exposed appurtenances, arranged and interconnected to provide localized touch-and-step voltage protection.
- O. Ground: An electrical connection to earth, normally comprised of a bare conductor.
- P. HVAC: High voltage alternating current (generally 69kVA or larger)
- Q. Lead, Lead Wires, Continuity Bond, and Cable: Insulated copper conductor; the same as wire.
- R. Pipe-to-Soil Potential (also Structure-to-Earth Voltage or CP potential): The difference in voltage (potential) between the subject metallic structure and the electrolyte in which it is buried or submerged, as measured to the standard specified reference electrode placed in contact with the electrolyte.
- S. Shock hazard: A condition considered to exist at an accessible part in a circuit between the structure and the earth whereby a steady-state AC voltage of 15 volts or more or a source capacity of 5 milli-amps or more is recognized as a hazardous condition.

1.04. SYSTEM DESCRIPTION

- A. System Requirements: Materials and equipment shall be new and the manufacturer's latest standard design that complies with NACE standards for AC mitigation.
- B. Performance Requirements:
 - 1. Show evidence of proper AC mitigation to eliminate any shock hazards and AC related corrosion in areas where piping will be collocated within 500 feet of any HVAC (generally 69kVA or greater) overhead powerlines.
 - 2. Show evidence of UL approval where UL standards exist and product listings are available.
 - 3. Conform to the National Electrical Code (NEC) and applicable federal, state, and local laws, codes, and regulations.
 - 4. When requirements of specifications or drawings exceed those of codes or the manufacturer's instructions, requirements of Specifications or Drawings prevail

1.05. SUBMITTALS

A. Submittals for Review:

1. Product data:

- a. Manufacturer's catalog cuts for all materials.
- b. Include manufacturer's name and provide sufficient information to show that materials meet the requirements of the project.

2. Quality Control:

- a. NACE certified personnel shall oversee the installation of all AC mitigation including, but not limited to, continuity bonding, electrical isolation, anode installations, test pedestals, gradient mats, solid state decouplers, etc. and test all components to ensure they are fully operational and providing adequate AC mitigation of each asset.
- b. NACE qualifications of CONTRACTOR personnel and Cathodic Protection Specialist (CP4).
- c. AC Mitigation Testing Plans and Procedures
 - (1) All testing plans and procedures shall be in accordance with the requirements herein and prepared by the CONTRACTOR's Cathodic Protection Specialist (CP4).
- d. Copies of field-collected data, including:
 - (1) Record drawings of installation and construction of each AC mitigation device; accurate location and type of grounding, wires, conduits, isolation devices, and other components.
 - (2) Field test reports.
 - (3) A Findings and Recommendations report of all captured data signed and stamped by the CONTRACTOR's Cathodic Protection Specialist (CP4).

- (a) Summary of design, construction, and testing to include all pertinent information relating to the AC mitigation on this project.
- (b) Summary of the identification and output of any influencing AC power sources, their configuration, and GPS coordinates.
- (c) Summary of location and plots of any dataloggers installed to measure any AC currents.
- (d) Final AC mitigation measurements.
- (e) Analysis and discussion of any deficiencies identified and recommendations to correct such deficiencies.

3. Operation and Maintenance Manuals

1.06. QUALITY ASSURANCE

A. Contractor's Qualifications

- 1. A minimum of 10 years of experience of AC mitigation and testing of comparable size and complexity.
- 2. Five comparable projects completed in the last 5 years for review and approval.

B. Cathodic Protection Specialist Qualifications

- 1. Currently certified by NACE as a Cathodic Protection Specialist (CP4).
- 2. Perform field observation and oversee testing services during installation of AC mitigation components associated with the project.
- 3. Verify proper installation and operation of all AC components.
- 4. Complete all data analysis and evaluation and provide a final findings and recommendations report.

C. Manufacturer's Qualifications

- 1. Regularly engaged on a full-time basis in the manufacture of products in this Section for a minimum of 5 years.

2. Provide certification that all materials and components meet the requirements of Drawings and Specifications; include references for the applicable section of the Specifications and Drawing details.

D. Field Supervision

1. Provide a superintendent or foreman to supervise the construction site. Visit the site for testing and specification compliance verification a minimum of once every two weeks or more frequent as needed.
2. Currently certified by NACE as a CP 2 or higher.
3. Minimum of 4 years of experience in corrosion control and AC mitigation.

1.07. DELIVERY, STORAGE, AND HANDLING

A. AC Mitigation Materials

1. Store off the ground.
2. Protect against weather, condensation, and mechanical damage.
3. Handle with care.
4. Do not sharply bend or tightly coil the wire.
5. Replace equipment or materials damaged in shipment or installation.

PART 2 - PRODUCTS

2.01. MANUFACTURERS

- A. Use of the manufacturer's name and model or catalog number is for the purpose of establishing a standard of quality and the general configuration desired.
- B. Substitutions: As approved by ENGINEER if considered equal.

2.02. SUPPLIERS

- A. Supplier: Farwest Corrosion, Denver, CO or MESA Products, Denver, CO
- B. Submit alternate suppliers for approval.

2.03. MATERIALS

A. Zinc Ribbon

1. Material: Zinc alloy meeting the requirements of ASTM B418, Type II.
2. Anode core: Continuous galvanized steel wire, 0.130-inch diameter.
3. Weight: 0.60 pound per linear foot
4. Dimensions: 1/2-inch wide by 9/16-inch thick.
5. Minimum lengths: As required.
6. Zinc Ribbon Lead Wire Connection:
 - a. Lead Wire:
 - (1) No. 4 AWG red, stranded, copper conductor with RHW/XLP insulation.
 - (2) Length: Sufficient to reach the test station terminal head or piping without splicing additional wire. Reference detail drawings for exact lengths required.

B. Test Pedestals

1. Description: Polycarbonate junction box (NEMA 6P), standard product of the recognized manufacturer.
2. Minimum inside box dimensions: 18 inch x 16 inch x 10 inch deep or larger, if required to provide proper access to all items.
3. Provide with:
 - a. One-piece of oil resistant gasket to be mounted inside the door to form an oil-tight and dust-free seal.
 - b. A locking lid and a hasp for a padlock.
 - c. Separate panel board:
 - (1) For the attachment of SSD installed on right.

- (2) Accommodate the test station head and RMU.
 - (3) Material: A minimum 3/16-inch micarta or cross-laminated phenolic sheet.
 - d. Test station head:
 - (1) Cott Big Fink, 3" diameter, 7 terminal model test head
 - (2) Test station head shall have 3" PVC threaded collar and blue cover
 - (3) Terminal board hardware shall consist of stainless steel or nickel-plated brass and consist of a minimum of seven (7) ½ inch diameter by 1.25 inches long studs with double nuts, flat washers, and lock washers.
 - 4. Label all wires within test pedestal as listed below with pipe diameter, material type, and/or wire function.
- C. Wire Labeling:
- 1. Design:
 - a. Wire labeling shall be permanent, heat shrinkable sleeves.
 - b. Shall be weather resistant/UV light resistant with matte finish.
 - c. Install marking sleeve within 6" of termination. Marking sleeve shall be clearly visible.
 - 2. Acceptable Manufacturers:
 - a. Epson LabelWorks
 - b. Owner or Designated Representative approved equal.
- D. Solid State Decoupler
- 1. SSD Model: Dairyland SSD-2/2-5-100-R
 - a. Threshold Voltage: -2/+2V
 - b. AC Fault Current: 5kA

- c. Rated Lightning Surge Current: 100,000 Amps
 - d. Steady state current: 45 Amps
- E. Remote Monitoring Unit:
 - 1. Sources: Pipeline Watchdog Product Line by Elecsys (no substitutions)
 - 2. Remote Monitoring Units for AC mitigation monitoring locations:
 - a. Watchdog Tracker B
 - b. Confirm telemetry with manufacturer if a satellite or cellular unit is required
 - c. Include systems installation accessory kit from manufacturer
 - d. Powered by lithium battery for 3-5 years.
- F. Current Transformer
 - 1. Sources: MagneLab
 - 2. Rated input current from 5-100 amps
 - 3. Output 0.333 Volt AC at rated current w/ Linearity accuracy $\pm 0.50\%$ or better from 10% to 130% of rated current.
 - 4. Inside diameter: minimum 0.75 inches or larger to fit around SSD pipe leads.
- G. Stationary Reference Electrodes
 - 1. Copper/copper sulfate reference electrode material designed for minimum 20-year useful life as manufactured by GMC Electrical.
 - 2. Reference electrode shall contain one (1) #14 AWG, stranded, yellow RHH/RHW insulation, lead wire for connection. Recommend 50 feet minimum.
 - 3. Reference electrode to be pre-packaged with a low resistivity backfill formulated to retain moisture and maintain stability.
- H. Metallic AC/DC Coupons

1. DC coupons: Metallic with an exposed surface area of 10 square centimeters.
2. AC Coupons: Metallic with an exposed surface area of 1 square centimeters.
3. Coupon shall contain two (2) #12 AWG, stranded, RHW/XLP insulation, lead wires for connection. Recommend 50 feet minimum. Green wire insulation for DC coupons and red wire insulation for AC coupons.
4. Ensure metallic coupon is the same material and composition as the structure under cathodic protection.
5. Approved manufacturers: McMiller Co. Inc. or approved equivalent

I. Exothermic Welds

1. All electrical cable connections to the underground piping or metallic fittings shall be made by an exothermic weld.
2. Exothermic type weld materials for pipeline connections shall include the proper size and type of weld cartridges and welder molds for use on ductile iron or steel pipe as manufactured by Erico Products Inc. CADWELD PLUS model or approved equivalent.
3. Weld materials shall be compatible to the pipe material as recommended by the thermite weld manufacturer.
4. Copper sleeves specifically designed for exothermic welding shall be crimped on all bare wire ends of #8 AWG or smaller gauge wires prior to exothermic welding to improve mechanical strength and thermal capacity.

J. Di-Electric Coatings

1. Denso Protal 7125 repair coating or Owner or Designated Representative approved equivalent.
2. All waterline pipe and pipe fittings shall be furnished with a factory applied coating as specified in other sections. The factory applied coatings shall be inspected prior to installation and shall be installed in accordance with the manufacturer's recommendations.
3. All bare line pipe, uncoated flange bolts, uncoated mechanical fitting bolts, and other uncoated bolts, nuts, flanges, or fittings with metallic composition shall be

protected with wax-tape primer and #1 wax-tape as manufactured by Trenton Corporation or approved equivalent and applied to a thickness of 20 mils.

- K. Plastic Conduit for Cathodic Protection Sheathing (below grade applications)
 - 1. Diameter: Sized to match application.
 - 2. Schedule 40 polyethylene (PE) or polyvinyl chloride (PVC) plastic pipe.
- L. Wire
 - 1. Insulated stranded or solid copper wire as specified.
 - 2. Wire size, type, and insulation type: As specified in this Section and as depicted on Drawings:
 - a. Pipe Test Leads: #8 AWG, Stranded, RHW/XLP
 - b. Pipe Leads for SSD: #2 AWG, Stranded, HMWPE
 - c. Zinc Ribbon Connections: #4 AWG, Stranded, RHW/XLP
 - d. AC/DC Coupons: #12 AWG, Stranded, RHW/XLP
 - 3. Wire insulation color: Indicates the function of each wire as shown on the Drawings.
 - a. Blue: Pipe test leads
 - b. Black: Pipe leads for SSD
 - c. Green: DC Coupons
 - d. Red: AC Coupons
 - e. Yellow: PREs
 - f. Red: Zinc Ribbon
- M. In-Line Tap Slices for Cables (use only if approved by ENGINEER):
 - 1. "C" taps made of conductive wrought copper.
 - 2. Sized to fit the wires being spliced.

3. Apply compression connectors the proper crimp tool and die recommended by the manufacturer for the wire and the tap connector size.
 4. "Butt" type wire splice connectors are acceptable for #8 AWG or smaller splices.
 5. Electrical splicing tape and coating:
 - a. Sources: Scotch 130C tape, Scotch Super 88 tape, and Scotchkote Electrical Coating as manufactured by 3M Products.
 - b. 30 mil linerless rubber high voltage splicing tape and 7 mil vinyl electrical tape suitable for moist or wet environments.
 - c. Electrical Connectors: Tin or nickel plated copper, brass, bronze, or stainless steel for electrical conductivity and atmospheric corrosion resistance.
- N. Wire Terminals: Burndy series
- O. CP Warning Tape: 3" plastic, APWA blue, non-detectable, marked "Caution Cathodic Protection Cable Buried Below"

PART 3 - EXECUTION

3.01. GENERAL

- A. Contractor is responsible for ensuring all equipment, piping, and other metallic objects are properly grounded to avoid shock hazards to personnel when working in areas of piping that is collocated (within 500 feet) of any HVAC (69 kVA or greater) powerlines. Contractor shall designate a competent person to be in charge of all electrical safety and proper grounding procedures during construction.
- B. During construction of metallic structures in areas of AC influence, the following minimum requirements are prescribed:
 1. On long metallic structures paralleling AC power systems, temporary electrical grounds shall be used at intervals not greater than 1,000 feet with the first ground installed at the beginning of the section. Under certain conditions, a ground may be required on each individual pipe segment or sections as it is strung along the ROW.

2. All temporary grounding connections shall be left in place until immediately prior to backfilling. Sufficient temporary grounds shall be maintained on each portion of the structure (i.e. blow-off, ARV, test station, vault, etc.) until adequate permanent grounding connections (i.e. zinc ribbons) have been installed.
 3. All grounding cables shall first be attached to the grounding component and then securely attached to the affected structure. Removal shall be in the reverse order. Properly insulated tools or electrical safety gloves shall also be used to minimize shock hazards.
 4. Metallic construction sheds, trailers, equipment, fences, or other temporary structures shall be properly grounded if subject to hazardous AC influence. Rubber tire equipment and trailers shall contain grounding chains while working in areas of hazardous AC influence.
- C. Do not work next to power lines during times of high lightning activity.
- D. Install and work around above grade and underground AC power lines and oil and gas pipelines with extreme care; follow the minimum separation distances in accordance with foreign company requirements and regulations. CONTRACTOR is required to identify and notify all foreign owners of pending construction and schedule of when line crossings will occur.
- E. Complete AC mitigation installations, wire connections, splices, placement, and backfill operations during daylight conditions.
- F. Install AC mitigation system components, such as splices, bonds, and wire installation when ambient temperature is above 15°F and rising in order to minimize damage to materials and insulation.
- G. Bury all wiring, conduits, and other components with a minimum of 24-inches of cover.
- H. Do not thermite weld or utilize open flame or torches in areas of flammable vapors or airborne particles where a fire or explosion could result.
- I. Changes to the locations of components due to field conditions must be approved in writing by OWNER.

3.02. INSTALLATION

A. Insulating Stone Installation

1. Remove topsoil to a uniform depth of approximately 6" in an area that extends at least in an 8ft square centered around test pedestals. Install crushed limestone a minimum depth of 6".

B. Test Pedestals

1. Determine location of test pedestals based on actual site conditions and as approved by ENGINEER.
2. Locate test pedestals as depicted on Drawings.
3. Attach test wires to pipe and wrap wires around pipe for strain relief.
4. Locate all test pedestals behind curbs, outside of roadways, and in areas that are accessible for personnel.
5. Make wire connections to test station terminal boards with crimp-on spade lug terminals.
6. Wire labels and markings:
 - a. Label and marking materials should be suitable for permanent identification.
 - b. Position markers in boxes so that they do not interfere with operation and maintenance.
 - c. Include pipe diameter, material type, and wire function, as applicable.

C. Wire Connections

1. Use thermite weld method for electrical connection of copper wire to metallic surfaces. Follow manufacturer's procedures for installation. Assure that the pipe or fitting wall thickness is of sufficient thickness that thermite weld process will not damage the integrity of the pipe or fitting or protective lining.
2. After cooling, remove all weld slag and visually inspect wire connection. Remove and replace any defective connections.
3. Install Denso Protal 7125 repair coating over each completed connection to the pipeline.

4. Maintain a minimum of 6 inches of separation between any two wire connections.

3.03. FIELD QUALITY CONTROL

A. Preservation, restoration, and cleanup:

1. Keep the site neat and orderly at all times.
2. Remove excess equipment and materials when required by prevailing conditions.
3. Confine operations to construction easements and work areas.
4. Restore the site to a condition equivalent to the original condition to the satisfaction of the ENGINEER and the landowner.
5. Prevent contamination of project area:
 - a. Do not dump or spill oil, fuel, solvents, coatings, rubbish, or similar materials on the ground or in or near streams or wetland areas.
 - b. Use caution to prevent stream or groundwater contamination.
 - c. Conform to federal, state, and local regulations.
6. Touch up scratches, scrapes, and chips in the interior and exterior surfaces of devices and equipment with finishes matching as nearly as possible the type, color, consistency, and type of surface of the original finish.
7. If extensive damage is done to equipment paint surfaces, completely refinish to equal or better than factory finish.
8. Repair damage to concrete and asphalt sidewalks, curbs, roads, and driveways.
9. If subsequent trench or undercrossing settlement, cracking, subsidence, or other indication of failure occurs within the warranty period, promptly repair or replace at the CONTRACTOR's sole expense.

3.04. AC MITIGATION COMMISSIONING AND TESTING

- #### A.
- When construction is complete, notify the ENGINEER and provide a minimum of 2 weeks' notice that the installation is ready to be turned on.

- B. CONTRACTOR's Cathodic Protection Specialist (CP4) shall develop a test plan and submit to the ENGINEER for approval prior to completing any testing.
- C. Testing to be performed by the CONTRACTOR's Cathodic Protection personnel.
- D. Energize installation as per the approved testing plan. Removed all temporary grounding used during construction after permanent grounding systems have been connected.
- E. Operating Test: Conduct a series of tests to demonstrate that equipment and material are installed correctly and operating properly for initial approval.
- F. Functional testing (to be completed upon completion of pipeline construction): At a minimum, provide the following tests:
 - 1. Commission all AC mitigation devices and measure native and mitigated AC structure-to-soil potentials of the pipeline at each test station and AC mitigation component using applicable equipment. Include all test stations, isolation devices, bonded segments, above grade appurtenances, surrounding metallic structures, and other identified locations.
 - 2. Follow NACE SP21424 for recommended testing procedures. Obtain both AC and DC potentials at all test stations and appurtenances. Dataloggers should be installed at each AC monitoring test station to record AC conditions for a minimum of seven (7) days.
 - 3. Note any deficiencies, changes, or issues from conformed drawings and specifications. Provide a list of deficiencies to the OWNER and correct or repair all items prior to final testing.
- G. Final Testing (to be completed 30 days after functional testing and/or connections of all AC mitigation devices)
 - 1. Make adjustments in the output of the system; conduct sufficient testing throughout the network of protected structures and piping to ensure proper installation and AC grounding levels.
 - a. Locate, correct, and retest system defects or incomplete work identified.
 - 2. Obtain final polarized DC and AC structure-to-soil potentials of pipeline at each test station and AC mitigation component using applicable equipment. Include all

test stations, isolation devices, bonded segments, above grade appurtenances, surrounding metallic structures, and other identified locations.

- H. Warranty Testing (to be completed 30 days prior to end of warranty period or approximately 1 year after installation)
 - 1. Make adjustments in the output of the system; conduct sufficient testing throughout the network of protected structures and piping to ensure proper installation and AC grounding levels.
 - a. Locate, correct, and retest system defects or incomplete work identified.
 - 2. Obtain final polarized DC and AC structure-to-soil potentials of pipeline at each test station and AC mitigation component using applicable equipment. Include all test stations, isolation devices, bonded segments, above grade appurtenances, surrounding metallic structures, and other identified locations.
- I. Locate, correct, and retest system defects or incomplete work identified during functional and final testing or warranty inspections at no additional cost to the OWNER.
 - 1. The CONTRACTOR shall assist the ENGINEER and OWNER in the performance of such additional tests by providing electrical contacts and physical access to the pipe. This work, and any subsequent repairs and additional testing shall be performed at no additional cost to the OWNER.
- J. Data Analysis
 - 1. CONTRACTOR's Cathodic Protection Specialist (CP4) shall analyze and review all AC data and providing the following minimal items within the analysis:
 - a. Tabular listing of areas where possible AC induction may be occurring and/or not properly mitigated in regards to shock hazards and personnel safety. Clearly identify any areas with AC voltage greater than 15 volts and AC current density that exceed a time-weighted average of the following:
 - (1) 30 A/m² if the DC current density exceeds 1 A/m²
 - (2) 100 A/m² if the DC current density is less than 1 A/m²

- b. Possible anomaly areas due to AC coating defects, stray currents, electrical shorts, failing electrical isolation devices, or other issues.

K. As-Built, Reporting, and Documentation

1. Provide a final chronological installation and testing report to include:
 - a. Record drawings of installation and construction of AC mitigation system. Include accurate location and type of anodes, wires, conduits, pipe connections, test stations, and electrical isolation devices.
 - b. NACE qualifications of project personnel and CONTRACTOR's Cathodic Protection Specialist (CP4).
 - c. Changes, modifications, and alterations from plans.
 - d. Comments relative to the Project.
 - e. Tabulated reports of the following:
 - (1) Open-circuit potentials of zinc ribbons
 - (2) Native AC potential measurements
 - (3) Energized AC potential measurements
 - (4) Data logging results
 - (5) Summary of location, GPS coordinates and plots of any dataloggers installed to confirm proper DC and AC potentials.
 - (6) Include 15 volt AC criteria line on all plots.
 - (7) All reports shall contain both permanent reference electrode readings and portable reference electrode readings.
 - f. Failures, defects, and any repairs.
 - g. Retesting information.
 - h. Findings and Recommendations.
 - i. Operations and Maintenance manual.

2. Report should be signed and sealed by the CONTRACTOR's NACE certified personnel (Cathodic Protection Specialist CP4) and submitted for approval by the ENGINEER and OWNER.

END OF SECTION

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SECTION 26 43 00

SURGE PROTECTIVE DEVICES

PART 1 - GENERAL

1.01. SECTION INCLUDES

- A. Surge protective devices for branch panelboard locations.

1.02. RELATED REQUIREMENTS

- A. Section 26 05 26 - Grounding and Bonding for Electrical Systems.
- B. Section 26 24 16 - Panelboards.

1.03. ABBREVIATIONS AND ACRONYMS

- A. SPD: Surge Protective Device.

1.04. REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction; 2023.
- B. NEMA EN 10250 - Enclosures for Electrical Equipment (1000 Volts Maximum); 2024.
- C. NFPA 70 - National Electrical Code; Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- D. UL 1449 - Standard for Surge Protective Devices; Current Edition, Including All Revisions.

1.05. SUBMITTALS

- A. See Section 01 33 00 - Submittals, for submittal procedures.
- B. Product Data: Include detailed component information, voltage, surge current ratings, repetitive surge current capacity, voltage protection rating (VPR) for all protection modes, maximum continuous operating voltage (MCOV), nominal discharge current (I-n), short circuit current rating (SCCR), connection means including any required external overcurrent protection, enclosure ratings, outline and support point dimensions, weight, service condition requirements, and installed features.

- C. Certificates: Manufacturer's documentation of listing for compliance with the following standards:

- 1. UL 1449.

- D. Operation and Maintenance Manuals

1.06. QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07. DELIVERY, STORAGE, AND PROTECTION

- A. Store in a clean, dry space in accordance with manufacturer's written instructions.

1.08. FIELD CONDITIONS

- A. Maintain field conditions within manufacturer's required service conditions during and after installation.

1.09. WARRANTY

- A. Manufacturer's Warranty: Provide a minimum five year warranty covering repair or replacement of surge protective devices showing evidence of failure due to defective materials or workmanship.

PART 2 - PRODUCTS

2.01. MANUFACTURERS

- A. Factory-installed, Internally Mounted Surge Protective Devices:

- 1. Same as manufacturer of equipment containing surge protective device, to provide complete listed assembly including SPD.

2.02. SURGE PROTECTIVE DEVICES - GENERAL REQUIREMENTS

- A. Description: Factory-assembled surge protective devices (SPDs) for 60 Hz service; listed, classified, and labeled as suitable for the purpose intended; system voltage as indicated on the drawings.

- B. Unless otherwise indicated, provide field-installed, externally-mounted or factory-installed, internally-mounted SPDs.
- C. List and label as complying with UL 1449, Type 1 when connected on line side of service disconnect overcurrent device and Type 1 or 2 when connected on load side of service disconnect overcurrent device.
- D. Protected Modes:
- E. UL 1449 Voltage Protection Ratings (VPRs):
 - 1. 208Y/120V System Voltage: Not more than 1,000 V for L-N, L-G, and N-G modes and 1,200 V for L-L mode.
 - 2. 240/120V System Voltage: Not more than 1,000 V for L-N, L-G, and N-G modes and 1,200 V for L-L mode.
- F. UL 1449 Maximum Continuous Operating Voltage (MCOV): Not less than 115% of nominal system voltage.
- G. Enclosure Environment Type per NEMA EN 10250: Unless otherwise indicated, as specified for the following installation locations:
 - 1. Outdoor locations: Type 3R.

PART 3 - EXECUTION

3.01. EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that the service voltage and configuration marked on the SPD are consistent with the service voltage and configuration at the location to be installed.
- C. Verify that electrical equipment is ready to accept connection of the SPD and that installed overcurrent device is consistent with requirements of drawings and manufacturer's instructions.
- D. Verify system grounding and bonding is in accordance with Section 26 05 26, including bonding of neutral and ground for service entrance and separately derived systems where applicable. Do not energize SPD until deficiencies have been corrected.

- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02. INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship).
- B. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- C. Do not energize SPD until bonding of neutral and ground for service entrance and separately derived systems is complete in accordance with Section 26 05 26 where applicable. Replace SPDs damaged by improper or missing neutral-ground bond.

3.03. CLEANING

- A. Repair scratched or marred exterior surfaces to match original factory finish.

END OF SECTION

SECTION 31 09 13

GEOTECHNICAL INSTRUMENTATION AND MONITORING

PART 1 - GENERAL

1.01. DESCRIPTION:

- A. This section includes the requirements for the installation, monitoring, and removal of geotechnical instrumentation for monitoring of ground movements within and around tunnel and shaft excavations, as well as movement of existing utilities and structures adjacent to tunnels and shafts.
- B. The Scope of Work to be performed under this section includes:
 - 1. Installing geotechnical instrumentation as shown on the Contract Drawings.
 - 2. Monitoring, by survey, the geotechnical instrumentations at the frequencies and to the precision stated herein.
 - 3. Removing the geotechnical instrumentation as described herein.
 - 4. Labor, material, tools, equipment, and incidentals necessary to complete the work described above.
- C. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements. The Contractor shall select and utilize methods and equipment compatible with the dimensions of the tunnels shown and with anticipated geologic conditions described in the Geotechnical Baseline Report (GBR).

1.02. REFERENCES:

- A. Geotechnical Reports
 - 1. Report dated April 17, 2026 prepared by Brierley Associates entitled "Geotechnical Baseline Report, Thornton Water Project – Segment F.1"
 - 2. Report dated July 15, 2026 prepared by CMT entitled "Geotechnical Data Report, Thornton Water Project – Segment F.1"
- B. Applicable Standards:

1. Perform work in accordance with all applicable federal, state, and local regulations, codes, and standards. In the event of conflict, comply with more stringent requirement.
2. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR Part 1926 - Safety and Health Regulations for Construction.

1.03. DEFINITIONS:

- A. Monitoring Point Array: A grouping of Surface Monitoring Points installed at a specified spacing as shown on the Construction Drawings.
- B. Optical Survey Targets. Reference points attached to structures or railroad ties to monitor movements with optical survey methods.
- C. Surface Monitoring Points: A marker or point fixed to the ground surface and/or structures that is monitored using survey control to determine vertical and horizontal displacements that may occur during construction.
- D. Utility Monitoring Points: Each Utility Monitoring Point shall consist of a plastic pipe casing as shown on the Construction Drawings that exposes the utility and retains the ground to allow for readings of a center rod.

1.04. QUALIFICATIONS:

- A. The Geotechnical Instrumentation Contractor shall be experienced in the installation of ground and structure monitoring instruments. The Geotechnical Instrumentation Contractor performing the work shall have performed, installed, and monitored geotechnical instrumentations for a minimum of five years on at least three separate projects.
- B. The Contractor's Instrumentation Surveyor must be a licensed professional surveyor in the State of Colorado and have previous similar experience surveying for the detection of structure and ground deformations.
- C. The Instrumentation Specialist shall have at least three years of experience with the installation, maintenance and monitoring of geotechnical instrumentation similar to those specified herein.

1.05. SUBMITTALS:

- A. Submit in accordance with Section 01 33 00.
- B. At least 90 days prior to the start of work, all submittals, including drawings and calculations, shall be required for the sole purpose of providing Engineer sufficient details to confirm that the Contractor planned work and work in progress is in accordance with Contract Documents. Engineer's review shall not be construed to relieve Contractor in any way of responsibilities under the Contract. Do not begin work on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer.
- C. Submit a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.
- D. Submit the following qualifications:
 - 1. The name and qualifications of the Geotechnical Instrumentation Contractor.
 - 2. The name and qualifications of the Instrumentation Surveyor.
 - 3. The name and qualifications of the Instrumentation Specialist.
- E. Preconstruction: Submit a Geotechnical Instrumentation and Monitoring Work Plan, including the following:
 - 1. List permits, and third party approvals required to perform the work.
 - 2. Description of methods and materials for installing and protecting instruments.
 - 3. For all instrumentation installed in boreholes, a proposed schedule for installing instruments, detailed step by step procedures for installation, including post installation acceptance test, together with a sample installation record sheet. The installation procedures shall include:
 - a. Specifications for proposed grout mixtures, including commercial names, proportions of admixtures and water, mixing sequence, mixing methods and duration, pumping methods and tremie pipe type, size and quantity.
 - b. Drill casing or auger type and size.

- c. Method for overcoming buoyancy of instrumentation components during grouting.
 - d. Method of sealing joints in pipes and casings to prevent ingress of grout.
- 4. Submit all applicable manufacturer's literature describing operation and maintenance procedures for the instrumentation. Provide manufacturer's brochures on each product. Provide product description and drawings, along with samples where applicable.
- F. Prior to instrument installation submittals, as applicable, a certificate of calibration that the instrument is working correctly and has no defects or missing parts.
- G. Prior to starting shaft or tunnel excavation in any reach, submit the initial readings of all geotechnical instruments and the results of the preconstruction survey. Baseline Readings: Prior to the start of excavation, the Contractor shall read required instrumentation and submit the baseline readings.
 - 1. Preconstruction survey shall provide photographic, video, or written observations of the conditions of third party structures, utilities, pavements, and facilities that may be affected by construction.
- H. Installation Records: Within five calendar days of installation of each instrument, submit drawings showing the installed location, the instrument identification number, the instrument type, the installation date and time, established elevations, initial elevations, offset and stationing, initial coordinates, boring logs, and the anchor to tip elevation(s) and instrument length, when applicable. Also furnish details of installed instruments showing all dimensions and materials used, a separate statement describing installation procedures for each instrument, and as built drawings of each instrument including depths, lengths, elevations, and dimensions of key elements.
- I. Construction. Submit the following during construction within the specified time restrictions:
 - 1. Reporting: The Contractor shall provide data from readings of all instruments to the Engineer within one working day of obtaining the information. The data shall include, but are not limited to, the following:
 - a. A cumulative history of readings and proximity of the excavation to the instrument location at the time of reading.

- b. A plot of measured values versus time, including a time history of construction activity likely to influence such readings.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01. GENERAL:

- A. The Contractor shall conduct a preconstruction survey of the condition of existing adjacent surface structures, including pavement. The purpose is to aid in determining and evaluating tunneling induced damage.
- B. Instrumentation shall be installed at the locations shown on the Construction Drawings, or as directed or approved by the Engineer.
- C. Instrumentation installation: All instrumentation shall be installed, and the baseline reading taken a minimum of seven days prior to start of shaft excavation.
- D. Access: Provide and facilitate safe access to the instrumentation to the Engineer including keys for lock boxes.
- E. Surface protection: Roadway or lock boxes shall be provided for monitoring points installed in boreholes shall be flush with the ground surface in areas where the instrument may be damaged or be an impediment to other activities.
- F. Existing Conditions: Locate conduits and underground utilities in all areas where subsurface geotechnical instrumentation is to be drilled and installed. Subsurface geotechnical instrumentation locations shall be modified, as approved by the Engineer, to avoid interference with existing conduits, utilities, and foundation elements.
- G. Instrument Designation: A unique instrument identification number shall be assigned to each instrument and each point. The instrument identification number shall be clearly marked on each instrument in a nondestructive manner.
- H. Instrument Protection: All instruments and markings shall be protected to avoid being obstructed or otherwise damaged by construction operations or the public.

- I. Surveying: The location of the top of all instruments shall be surveyed to provide horizontal and vertical coordinates. Data shall be provided to the Engineer. Re-surveying from project control points shall be required monthly or more frequently to address potential disturbance or resolve conflicting data.
- J. Drilling from the Ground Surface: Instrumentation holes drilled from the ground surface shall be subject to the same permitting and drilling requirements as those for geotechnical exploration boreholes. Obtain necessary permits for each such instrument and conform to the permit requirements during drilling, installation, monitoring and abandonment.

3.02. SAFETY REQUIREMENTS:

- A. Methods of construction shall be such as to ensure the safety of the workers, project participants, the public, third parties, and adjacent property, whether public or private. The Contractor is solely and completely responsible for maintaining safe working conditions at the site at all times.

3.03. MAINTENANCE:

- A. Maintain clean working conditions at all times. All excess material, slush, contact grout spills, ponded water, and any other unused material or byproduct of the work shall be removed from the tunnel and the excavation daily.
- B. Damaged Installations: Protect the instruments from damage. Damaged installations shall be replaced or repaired prior to continuing excavation.
- C. Maintenance: Maintain the instruments by draining water and flushing debris from under protective covers and keeping covers locked and sealed at all times.

3.04. INSTALLATION:

- A. Project survey datum shall be as noted on the Construction Drawings.
- B. Should actual field conditions prevent installation of instruments at the location and elevations shown on the Construction Drawings or specified herein, obtain prior acceptance from the Engineer for new instrument location and elevation.
- C. Surface Monitoring Points: Surface Monitoring Points shall be located as shown on the Instrumentation Schedule in the Contract Drawings. After completion of installation,

the as-built location in horizontal position shall be determined to an accuracy of ± 0.1 ft and the elevation to an accuracy of ± 0.01 ft.

D. Utility Monitoring Points:

1. Utility Monitoring Points shall be installed on utilities as shown on the Instrumentation Schedule in the Contract Drawings.
2. The location of the utility in the field shall be determined and the pothole advanced to the top of the utility. The Contractor shall be responsible for any damage to the utility during installation of the Utility Monitoring Point.
3. After completion of installation, the as-built location in horizontal position shall be determined to an accuracy of ± 0.1 ft and the elevation of the top of the utility to an accuracy of ± 0.01 ft.

3.05. MONITORING:

- A. The Contractor shall take initial readings of all instruments to establish a baseline and provide the Engineer with this data. The baseline shall consist of at least three readings on three separate days. The baseline readings shall be used to determine the precision of each Geotechnical Instrument. For grouted instruments, the initial reading shall not begin until at least seven days after grout installation.

B. Frequency:

1. The Contractor shall read the Geotechnical Instrumentation and provide the Engineer with these data.
2. As a minimum, the Contractor shall read the instruments according to the following schedule:

Instrument Type	Inside Active Zone/Period^(a, b)	Outside Active Zone/Period^(a, b)
Surface Monitoring Points / Monitoring Point Arrays	Daily	Weekly / Monthly ^(c)
Utility Monitoring Points	Daily	Weekly / Monthly ^(c)

Notes:

- a) Active zone/period for tunnels is the time between the start of tunneling and three days after the completion of contact grouting for each tunnel, for the Surface monitoring points and Arrays.
 - b) Active zone/period for shafts is when the instrument is within 50 feet of the shaft, and from the beginning of shaft excavation and two weeks following the end of shaft backfilling.
 - c) Monthly prior to the instrument being in an Active Zone/Period, weekly once the instrument has passed the Active Zone/Period until movement substantially stops, and monthly thereafter until the tunneling component of the project is complete.
3. The Contractor shall perform additional monitoring as necessary to control construction and to ensure the safety of the work.

3.06. RESPONSE VALUES:

- A. The threshold and shutdown values are the cumulative amount of instrument deformation at which the Contractor must take some action to address. The Contractor shall abide by the following:

Instrument	Threshold Value ^(a)	Shutdown Value ^(a)
Surface Monitoring Points and Arrays	0.04 ft H and V for Shafts 0.04 ft H and V outside the RR ROW for Tunnels 0.01 ft H and V inside the RR ROW for Tunnels	0.08 ft H and V for Shafts 0.08 ft H and V outside the RR ROW for Tunnels 0.02 ft H and V inside the RR ROW for Tunnels
Utility Monitoring Points	Threshold and shutdown values shall be set by the Contractor with review of the Engineer based on the sensitivity of the utilities identified as requiring monitoring.	
Notes: a) Threshold and Shutdown Values shall be considered for both settlement and heave.		

- B. When a given response value is reached, the Contractor shall as follows:

1. Threshold Value: The Contractor shall meet with the Engineer within 24 hours of the occurrence to: 1) review the data and results, 2) review the construction

means and methods, and 3) determine what changes shall be made to control ground movement.

2. Shutdown Value: The Contractor shall stop tunnel or shaft excavation immediately and meet with the Engineer to develop a plan of action before excavation can be resumed.

3.07. FINAL DISPOSITION:

- A. Surface Monitoring Points: Remove all Surface Monitoring Points installed in soil. Points in pavement may remain or be removed and the pavement patched, at the option of the governing agency.
- B. For all underground instrumentation and instrumentation installed in bore holes:
 1. Remove protective housings and caps,
 2. Restore surface to the conditions existing prior to installation of the instruments, and
 3. Drill out and grout, or backfill grout in accordance with permits, and environmental laws and regulations.

END OF SECTION

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SECTION 31 23 00

EARTHWORK

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This Section includes excavation and shoring for structures; materials, testing, and fill adjacent to structures; and rock bases for structures.
- B. Refer to Section 31 23 43 for materials, testing, and installation for pipeline excavation, backfilling, and compacting.

1.02. REFERENCE STANDARDS

- A. ASTM International (ASTM):
 - 1. D75: Standard Practice for Sampling Aggregates.
 - 2. D698: Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft²) (600 kN-m/m²).
 - 3. D4253: Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 - 4. D4254: Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 - 5. D4718: Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles.
 - 6. D6938: Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
 - 7. D7382: Standard Test Methods for Determination of Dry Unit Weight and Water Content Range for Effective Compaction of Granular Soils Using a Vibratory Hammer.
- B. Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction, latest edition.

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit gradation for rock base material and aggregate base course.
- C. Temporary Excavation and Support Plan (Plan) for new below-grade structures:
 - 1. Submit a Temporary Excavation and Support Plan (Plan) to the Engineer a minimum of 30 calendar days prior to starting any onsite construction Work for excavation(s) and temporary support for new below-grade structures as designated on the Drawings. If the Contractor purchases, rents, installs, or mobilizes to the site any elements of any temporary support systems prior to the Engineer's review of the submittal, he does so at his own risk, and will not be due any additional compensation from the Owner if such elements are not subsequently used for the Work.
 - 2. The Plan shall include drawings showing locations, dimensions, and relationships of elements of the proposed temporary excavation(s) and any proposed temporary support system(s), details regarding the type(s) of support system(s), and design calculations required to substantiate the Plan.
 - 3. Design calculations and designs completed as part of the Plan shall be sealed, signed, and dated by one or more professional engineers registered in the State of Colorado with demonstrated competence and experience in relevant aspects of geotechnical and structural engineering. A detailed resume demonstrating the relevant experience and competence of the proposed professional engineer(s) shall be included in the Plan.
 - 4. For temporary excavation(s), the Plan shall include, but not be limited to, plan and section drawings clearly showing the location, extent and orientation of excavation slopes.
 - 5. For any proposed temporary support system(s)(e.g., sheetpiling, tiebacks, soil nailing, soldier piles and lagging, etc.), the Plan shall include type, location, size, and arrangement of all elements of the system; include plan and section drawings and details as necessary to fully illustrate the proposed temporary support system(s). Submit data sheets for all materials proposed to be used for any temporary support system(s).

6. The Plan shall include a detailed description of the sequencing and coordination with other Work (including dewatering) of the temporary excavation and support Work, including installation, maintenance, monitoring, and removal activities.
7. The Plan shall consider Owner access to existing facilities during construction. Existing access may need to be relocated during construction; such access modifications shall be coordinated with and approved by the Owner.
8. The Plan shall include the means and method for backfilling around the structure.
9. Engineer review of the Plan proposed by the Contractor will only be with respect to the basic principles of the methods the Contractor intends to employ. Review of the Plan by the Engineer shall not relieve the Contractor of the full responsibility for the adequacy and safety of the temporary excavation(s) and support system(s).
10. If any aspect of the temporary excavation(s) or support system(s) is modified during installation or operation, revise or amend the appropriate drawings and calculations and resubmit the Plan for review by the Engineer.

D. Submit results of any earthwork testing performed by Contractor to the Engineer.

1.04. TESTING FOR COMPACTION

- A. The Contractor shall, through services of an independent lab, test and determine conformance, under Construction Manager direction.
- B. The minimum frequency of testing shall be one (1) test per lift of fill material at each structure. The Engineer may require additional tests when deemed necessary to verify the state of the subgrade and materials placed within excavations.
- C. Contractor shall provide access to testing locations and cooperate with the testing representative and the Construction Manager during testing, including shutting down construction operations in the vicinity of the testing if requested.
- D. The density of soil in place shall be determined by nuclear methods, ASTM D6938. Compaction tests will be performed for each lift, layer, or area. Multiple tests in a lift or Work area may be required as deemed necessary by the Owner or Construction Manager. When additional testing is determined necessary due to a test location failing to meet the compaction requirements, testing at a greater frequency and

impacts to the progress of the Work from the additional testing will not be a basis for additional compensation to Contractor.

- E. Laboratory compaction control criteria shall be determined by ASTM D698 for fill. Laboratory compaction control criteria for imported cohesionless granular material shall be determined by either ASTM D4253 and ASTM D4254 for determination of relative density, or ASTM D7382 as determined by the Engineer. Where oversize particles are present in proposed general fill material, the compaction test results for maximum dry density and optimum water content shall be adjusted if necessary in accordance with ASTM D4718.
- F. Sample earth fill materials per ASTM D75.
- G. "Relative density" of cohesionless soils is as defined in ASTM D4253 and ASTM D4254.
- H. "Relative compaction" is the ratio, expressed as a percentage, of the in-place dry density to the laboratory maximum dry density.
- I. Compaction shall be deemed to comply with the specifications when no test falls below the specified relative compaction or relative density.

1.05. EXCESS AND UNSUITABLE MATERIALS DISPOSAL

- A. All excess spoil material generated during construction activities shall be completely removed from the Project site and disposed of offsite unless the Contractor can negotiate alternative disposal arrangements with impacted or adjacent landowners. It will be the full responsibility of the Contractor to coordinate and negotiate disposal arrangements including exact locations, access, disposal volumes, stockpile heights, grading, restoration, seeding, sediment control, and payment.

1.06. REMOVAL OF TEMPORARY FACILITIES

- A. Except as otherwise accepted in writing by the Owner, all temporary shoring or other temporary facilities installed by the Contractor for performance of the Work under this Section shall be removed and disposed of offsite when no longer required for the use it was intended.

PART 2 - MATERIALS

2.01. TYPE 1 FILL

- A. Type 1 fill is an imported non frost-susceptible material to be placed adjacent to structures where shown on the Drawings.
- B. Type 1 fill shall meet the gradation of CDOT Class 6 aggregate base.

2.02. ROCK BASE FOR STRUCTURES

- A. Rock base shall be CDOT No. 67 aggregate.

2.03. WATER FOR COMPACTION

- A. Water for compaction shall be free of organic materials and shall have a pH of 7.0 to 8.0, a maximum chloride concentration of 500 mg/L, and a maximum sulfate concentration of 500 mg/L.

PART 3 - EXECUTION

3.01. DEWATERING

- A. Refer to Section 31 23 19.

3.02. SEQUENCING AND SCHEDULING

- A. Excavation Support: Install and maintain temporary excavation support, as necessary to support excavations for new and existing structures on the property as well as utilities and roadways on adjacent property, and completed Work in accordance with the Temporary Excavation and Support Plan (Plan).
- B. Dewatering: Conform to applicable requirements of Section 31 23 19 prior to initiating any excavation within the limits of the permanent and temporary excavation support system. Maintain dewatering for the entire time that excavations are open in whole or in part, including continuously during cold weather conditions.

3.03. EXCAVATION

- A. Excavations shall have sloping faces, dewatering, sheeting, shoring, and bracing conforming with 29CFR1926 Subpart P – Excavations of OSHA requirements, other applicable Federal, State, or local rules and regulations, and the Standard General

Conditions of the Construction Contract as necessary to provide safe and stable site conditions for, and adjacent to, working within the excavations.

- B. Excavation is unclassified. Perform excavation to accomplish the construction regardless of the type, nature, or condition of the material encountered.

3.04. LIMITS OF FOUNDATION EXCAVATION

- A. Excavations shall be made to the lines, grades, and elevations shown on the Drawings, or as necessary to construct the Work.
- B. Excavations shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown on the Drawings and for working space, backfill, and site grading.
- C. Rock or other foundation material shall be cleaned of loose debris and cut to a firm, level, stepped, or serrated surface.
- D. Do not excavate for footings, slabs, or pipe below elevations indicated on the Drawings unless unacceptable material is encountered at the design subgrade elevation. Such conditions shall be brought to the attention of the Engineer. The Engineer will determine if additional excavation is required.
- E. Over-excavation done for the convenience of the Contractor and any unauthorized over-excavation shall be brought to the attention of the Engineer for required remediation.
- F. The Contractor shall bear all costs for correcting areas over-excavated for Contractor's convenience and unauthorized over-excavated areas. Such over-excavation and backfill will not be cause for any additional payment.

3.05. FOUNDATION SUBGRADE PREPARATION

- A. The bottoms of all excavations shall be firm, stable, and shall not deform or rut under the weight of workers and equipment prior to placing any bedding, backfill, or other materials in the excavation. If unstable conditions are encountered at the foundation subgrade elevation, the Construction Manager shall be notified. Remediation of unstable foundation conditions shall be performed at no additional cost to Owner if the unacceptable foundation conditions were caused by the Contractor's failure to dewater in accordance with the specified performance criteria.

- B. Protect subgrades from becoming saturated, frozen or otherwise damaged until backfill or concrete is placed.

3.06. PLACEMENT OF ROCK BASE

- A. Place rock base beneath structures where shown in the Construction Drawings, twelve (12) inches thick, in six (6) inch lifts, unless otherwise indicated. Compact each lift until aggregate is visually stable and keyed in and no noticeable movement is detected under foot.
- B. The crushed rock base shall slope and extend outwards to a minimum of twelve (12) inches beyond the structure base, floor slab, or footing.

3.07. FILL MATERIAL PLACEMENT PREPARATION

- A. Remove foreign materials and trash from the excavation before placing any fill material.

3.08. PLACING AND COMPACTING FILL MATERIAL

- A. General Requirements:
 - 1. Select equipment and employ means and methods to achieve the compaction requirements in this Section.
 - 2. Do not use any axle-driven equipment within three (3) feet of building walls, foundations, and other structures. Place and compact fill adjacent to concrete walls with hand-operated tampers, small walk-behind compactors, or other equipment that will not damage the structure.
 - 3. Do not place fill on frozen subgrade or previously placed and compacted fill.

3.09. PLACING AND COMPACTING TYPE 1 FILL

- A. Place Type 1 fill to the lines and grades shown on the Drawings or specified herein. Place fill in maximum 6-inch loose lifts and compact each lift to 95% maximum dry density, Modified Proctor. Moisture content $\pm 2\%$ optimum.
- B. The density of soil in place shall be determined by nuclear methods, ASTM D6938. Compaction tests will be performed for each lift, layer, or area. Multiple tests in a lift or Work area may be required as deemed necessary by the Owner or Construction Manager. When additional testing is determined necessary due to a test location

failing to meet the compaction requirements, testing at a greater frequency and impacts to the progress of the Work from the additional testing will not be a basis for additional compensation to Contractor.

- C. Determine laboratory moisture-density relations of soils by ASTM D1557.
- D. Sample backfill materials per ASTM D75.
- E. When the fill placement moisture content and/or percent compaction does not meet the Specifications, the Contractor shall immediately make adjustments in procedures as necessary to obtain the specified results. This shall not relieve the Contractor of the responsibility for meeting the compaction requirements in this Section on all fill placed.
- F. Materials not meeting the specified moisture content and/or percent compaction shall be reworked until acceptable results are obtained. Reworking may include removal, rehandling, reconditioning, rerolling, or combinations of these procedures. The Contractor shall not be entitled to additional compensation by reason of any work required to achieve the placement moisture content and percent compaction in these Specifications.

END OF SECTION

SECTION 31 23 19

DEWATERING AND CONTROL OF WATER

PART 1 - GENERAL

1.01. SUMMARY

A. Section Includes:

1. Designing, furnishing, constructing, installing, maintaining, operating, and removing systems to divert stream flows and surface water flow that could potentially flood the Work areas, and for control, collection, and disposal of groundwater required for proper construction of the Work.
2. Maintaining the foundations, subgrades, slopes and other parts of the Work free from water and dry as required for constructing each part of the Work.
3. Complying with all applicable environmental protection laws and requirements in operation of the groundwater and surface water control systems.
4. Removing components of water control systems not identified to remain after the systems are no longer required for proper construction of the Work.
5. No cofferdams or barriers are allowed in the floodplain.

1.02. REFERENCES

A. Geotechnical Reports

1. Report dated April 17, 2026, prepared by Brierley Associates entitled "Geotechnical Baseline Report, Thornton Water Project – Segment F.1" which is applicable to the project's tunnels and shafts.
2. Report dated July 15, 2026, prepared by CMT entitled "Geotechnical Data Report, Thornton Water Project – Segment F.1"

1.03. REQUIREMENTS

- ###### A. General - Design, furnish, install, maintain, monitor, and operate water control systems that will prevent entry of surface water flow into the construction areas and a groundwater dewatering system that will lower groundwater levels a minimum of two

(2) feet beneath excavation limits, while preventing loss of fines, boiling, quick conditions, or softening of foundation strata and maintaining stability of slopes and bottoms of excavations so that every phase of the Work can be performed in the dry. The dewatering operations shall be such that all subgrades and the slopes and bottoms of all excavations shall always be kept firm and in all respects acceptable to the Owner and Engineer as a stable foundation.

- B. Contractor shall design and install a water treatment system, if necessary, to comply with discharge limitation parameters.

1.04. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. The Contractor shall submit a Groundwater Dewatering and Surface Water Control Plan (Plan) to the Engineer for review at least 21 calendar days prior to starting any on-site construction Work for which the water control facilities are required. If the Contractor purchases, rents, installs, or mobilizes to the Site any elements of the water control systems prior to the Engineer's review and acceptance of the submittal, it does so at its own risk, and will not be due any additional compensation from the Owner if such elements are not subsequently used for the Work.
- C. The Plan shall include drawings showing locations, dimensions, and relationships of elements of each system and details regarding the types of various dewatering and water control facilities and design calculations required to substantiate the Plan.
- D. For control of surface water, the Plan shall include, but not be limited to, location of diversion channels, diversion dikes, cofferdams, site restoration, phasing of implementation or removal activities, and the Contractor's proposed cross-sections, arrangement, locations, heights and composition of proposed diversion channels, diversion dikes and cofferdams.
- E. For control of groundwater, the Plan shall include Contractor's proposed dewatering system design including, but not limited to, type, location, size, arrangement, and depths of sumps, pumping installations, well points, wells, and phasing of dewatering system(s) implementation and removal activities.
- F. Design calculations completed as part of the Plan shall be signed by a Professional Engineer registered in the State of Colorado, demonstrating compliance of the

proposed surface water diversion and groundwater dewatering plan with sound engineering practices and water quality protection permit requirements and goals.

- G. Submit data sheets to Engineer for all materials proposed to be used for the water control systems.
- H. Submit copies of any data acquired from the planning, installation and/or operation of the groundwater dewatering system to Engineer within seven days of receipt from others or development by Contractor of such data. Data may include but is not limited to boring (well) logs, pumping test results, and water level measurements whether in new or existing piezometers or new dewatering wells.
- I. Engineer review of the Plan proposed by the Contractor will be only with respect to the basic principles of the methods the Contractor intends to employ. Review by the Engineer shall not relieve the Contractor of the full responsibility for the adequacy of the water control systems.
- J. If any portion or element of the systems is modified during installation or operation, revise or amend the appropriate drawings and calculations and resubmit the Plan for review.
- K. Required well permits and discharge permits for dewatering wells shall be provided by the Contractor.
- L. Submit a bypass plan for each ditch and open water crossing. Bypass plan shall include at a minimum:
 - 1. Basis of flow assumptions.
 - 2. Pump size, type, and capacity.
 - 3. Backup pumping equipment in case of primary equipment failure.
 - 4. Site plan with water containment measures and layout.
 - 5. List of restrictions and work conditions required by the ditch or waterway owner.

PART 2 - MATERIALS

(NOT USED)

PART 3 - EXECUTION

3.01. GENERAL

- A. The Contractor shall review the available subsurface data for the site. It shall be the Contractor's responsibility to evaluate the subsurface conditions at the site with respect to required water control facilities, including any additional groundwater exploration, testing, or monitoring data obtained by the Contractor.
- B. The Contractor shall, at all times during construction, provide ample means and devices to remove promptly and dispose of properly all water entering excavations and keep the bottoms of the excavations firm and free of standing water until trench subgrade preparation is complete, backfill to be placed therein has been placed and compacted where specified, pipe or structures to be built therein are completed, and no damage from hydrostatic or artesian pressure, flotation, or other cause will result.
- C. Obstruction of surface drainage shall be avoided, and means shall be provided whereby storm water can be uninterrupted in existing gutters, other surface drains, or temporary drains.
- D. The groundwater dewatering operations shall be carried out in such a manner that no disturbance to the bearing soil or to soil supporting any other Work will result from the dewatering operations.
- E. Discharged water shall not cause siltation, erosion, flooding, water quality impacts, or other negative environmental impacts on natural waterways or other property; such discharge shall be in accordance with applicable Federal, State, and local regulations. At dewatering discharge locations, sediment ponds, hay bales, silt barriers or other control measures shall be installed as necessary to control and prevent siltation.
- F. The groundwater dewatering and surface water control systems shall be operated continuously, including weekends and holidays and during Work stoppages, as necessary to prevent flotation of partially installed piping or structures, and prevent any other surface or groundwater related damage to structures, facilities, subgrades, slopes or other Work.
- G. Ditch Company Requirements – There shall be no discharge of groundwater dewatering or surface water to the various irrigation ditches along the Project without prior written approval from the ditch companies.

3.02. INSTALLATION AND OPERATION

- A. The location of every element of the water control systems shall be such that interference with excavation and other construction activities is avoided to the extent practical or otherwise minimized. Locations shall be subject to review by the Engineer.
- B. When the water control systems do not meet the specified requirements, and as a consequence loosening or disturbance of the foundation strata, instability of the slopes or damage to the foundations or structures occurs, the Contractor shall supply all materials, labor, and perform all work for restoration of foundation soils, fill soils, slopes, foundations, or structures at no cost to the Owner.
- C. The operations of the Contractor's dewatering system shall result in groundwater being drawn down to a minimum of two (2) feet below the bottom of trench excavation to keep the trench excavation stable. Refer to Section 31 23 43 for trench stabilization.

3.03. REMOVAL

- A. All elements of Contractor's water control systems shall be removed from the site at the completion of the Work requiring the water control systems.

END OF SECTION

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SECTION 31 23 43

TRENCHING, BACKFILLING, AND COMPACTING

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials, testing, and installation for pipeline excavation, backfilling, and compacting.
- B. Refer to Section 31 23 00 for excavation and shoring for structures; materials, testing, and fill adjacent to structures; and rock bases for structures.

1.02. REFERENCE STANDARDS

- A. Wherever reference is made in this section to the LCRARS, such reference shall be understood to mean the "Larimer County Rural Area Road Standard", latest edition.
- B. Wherever reference is made in this section to the ROWCP, such reference shall be understood to mean the provisions provided in the Larimer County Right-of-Way Construction Permit.
- C. American Association of State Highway and Transportation Officials (AASHTO)
 - 1. T99: Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
 - 2. T180: Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
- D. ASTM International (ASTM)
 - 1. C33: Standard Specification for Concrete Aggregates
 - 2. C595: Standard Specification for Blended Hydraulic Cements
 - 3. C618: Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
 - 4. D75: Standard Practice for Sampling Aggregates.

5. D698: Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft²) (600 kN-m/m²)
 6. D1557: Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³) (2,700 kN-m/m³)
 7. D2419: Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
 8. D2434: Standard Test Method for Permeability of Granular Soils (Constant Head)
 9. D4253: Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
 10. D4254: Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
 11. D4718: Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
 12. D6938: Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
- E. Colorado Department of Transportation (CDOT) Standard Specifications for Road and Bridge Construction, latest edition.

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit method(s) of compaction including removal sequence of shoring where used.
- C. Submit gradation for imported sand bedding, squeegee, foundation stabilization rock, clay liner, and aggregate base course.
- D. Submit mix design for controlled low-strength material (CLSM) and flowable fill.
- E. Submit product information for filter fabric.

1.04. PIPE TRENCH DESCRIPTIONS

- A. Open Areas, See Drawing Detail 1/C-501)

1. Pipe Base

- a. The Pipe Base shall be defined as a layer of bedding material immediately below the bottom of the pipe or conduit and extending over the full trench width. Thickness of Pipe Base shall be as follows unless otherwise shown in the Drawings or otherwise described in the specifications for the particular type of pipe installed.

Pipe Diameter	Thickness of Pipe Base
Smaller than 4 inches	3 inches
4 inches through 16 inches	4 inches
18 inches and larger	6 inches

- b. Refer to the Drawings for locations where the Pipe Base may be CLSM or concrete encasement.

2. Pipe Zone

- a. The Pipe Zone shall include the full width of trench from the bottom of the pipe or conduit (top of Pipe Base) to a horizontal level above the top of the pipe, as specified below. Where multiple pipes or conduits are placed in the same trench, the pipe zone shall extend from the bottom of the lowest pipe to a horizontal level above the top of the highest or topmost pipe. Thickness of pipe zone above the highest top of pipe shall be as follows unless otherwise shown in the Drawings or otherwise described in the specifications for the particular type of pipe installed.

Pipe Diameter	Thickness of Pipe Zone Above Top of Pipe
6 inches or smaller	6 inches
8 inches and larger	12 inches

3. Refer to the Drawings for locations where the Pipe Zone may be CLSM or concrete encasement.

4. Trench Zone

- a. The Trench Zone includes the portion of the trench from the top of the Pipe Zone up to the existing ground surface and shall include any topsoil thickness.

- b. Refer to the Drawings for locations where the Trench Zone is backfilled with CLSM.
- B. Roadway Crossings, Larimer County Roads 11 and 54, See Drawing Detail 2/C-501
 - 1. Pipe Base
 - a. Same as Article A.1.
 - 2. Pipe Zone
 - a. Same as Article A.2.
 - 3. Flowable Fill Zone
 - a. The Flowable Fill Zone includes the portion of the trench from the top of the Pipe Zone to the bottom of the Roadway Zone in Larimer County gravel roadway crossing areas. If the resulting Flowable Fill Zone is less than 24 inches thick, the Roadway Zone shall extend to the top of the Pipe Zone and there shall be no Flowable Fill Zone.
 - 4. Roadway Zone
 - a. The Roadway Zone is the top of the trench where it crosses Larimer County gravel roads and includes the gravel surfacing. Refer to the Drawings for the depth of Roadway Zone.
- C. Roadway Installation, Larimer County Road 56, See Drawing Detail 3/C-501)
 - 1. For the parallel pipe installation in LCR 56, the trench section shall follow the requirements for Conventional Backfill provided in LCRARS.
 - 2. Initial Lift
 - a. The Initial Lift shall be comprised of both the Pipe Base and Pipe Zone. Refer to Articles A.1 and A.2.
 - b. Refer to the Drawings for locations where the Initial Lift is concrete encasement.
 - 3. Intermediate Lift

- a. The Intermediate Lift includes the portion of the trench from the top of the Initial Lift to the bottom of the Final Lift. If the resulting Intermediate Lift is less than 24 inches thick, the Final Lift shall extend to the top of the Initial Lift and there shall be no separate Intermediate Lift.

4. Final Lift

- a. Same as Article B.4.

PART 2 - MATERIALS

2.01. IMPORTED SAND BEDDING

- A. Placement Locations: Pipe Base, Pipe Zone, Initial Lift
- B. Imported sand shall conform to AASHTO M6 and have the following gradation:

Sieve Size	Percent (%)Passing By Weight
3/8-inch	100
No. 4	95 – 100
No. 8	80 – 100
No. 16	50 – 85
No. 30	25 – 60
No. 50	10 – 30
No. 100	2 – 10

- C. Imported sand shall have a coefficient of permeability greater than 0.014 measured in accordance with ASTM D2434 or a minimum sand equivalent of 30 per ASTM D2419. Imported sand shall have a saturated resistivity greater than 1,000 ohm-cm, a neutral pH, and chlorides less than 100 ppm.
- D. Squeegee shall be an acceptable alternative to AASHTO M6 sand bedding, but shall meet the following:
 - 1. Contain no clay balls, roots, or organic material and be unfrozen.
 - 2. Squeegee shall have the following gradation:

Sieve Size	Percent (%) Passing By Weight
3/8-inch	100
No. 200	0 – 3

- E. Modifications or substitutions to the imported sand bedding shall be approved by the Engineer. Substitutions may be considered based on material availability and per recommendations by the Geotechnical Engineer.

2.02. NATIVE EARTH BACKFILL

- A. Placement Locations: Trench Zone, Intermediate Lift
- B. Native earth backfill used in the trench zone shall be as described below:
 - 1. Native earth backfill used above the Pipe Zone or Intermediate Lift shall be excavated, thoroughly mixed, material free from roots, debris, rocks larger than 2 inches, organic matter, clods, clay balls, broken pavement, and other deleterious materials. The coarser materials shall be well distributed throughout the finer material.
 - 2. Backfill materials that are obtained from trench excavated materials to the extent such material is available shall be either screened directly into the trench or screened during the trenching operation. If screened during trenching, the material shall be maintained free of unscreened material during the handling and backfilling process. Hand selecting of rocks from earth as it is placed into the trench will not be permitted in lieu of the specified screening. Under no circumstances will native earth backfill be allowed or used in the Pipe Base, Pipe Zone, or Initial Lift areas.

2.03. CLSM FOR BACKFILL

- A. Placement Locations: Pipe Base, Pipe Zone, Trench Zone (Non-Larimer County Road Crossings)
- B. Controlled Low Strength Material (CLSM) shall consist of a mixture of Portland cement, aggregate, fly ash, water, and admixtures conforming to the following:
 - 1. Cement: ASTM C595, Type II, maximum of 50 pounds per cubic yard.
 - 2. Aggregate: ASTM C33 with no plastic fines.

3. The soluble sulfate content shall not exceed 0.3% by dry weight.
 4. Water: Potable quality.
 5. Water-Cement Ratio: 3.5:1 maximum.
 6. Fly Ash: Class C per ASTM C618, maximum of 250 pounds per cubic yard.
- C. Proportion the CLSM to be a flowable, nonsegregating, self-consolidating nonshrink slurry. The water content shall not exceed that required to provide a mix that will flow, can be pumped, and will maintain the soil in suspension without segregation of the aggregate while being placed. Proportion the aggregate, cement, and water either by weight or by volume. Use as little cement for each cubic yard of material produced as necessary to make the CLSM flowable.
- D. CLSM shall be limited to a maximum Removability Modulus (RE) of 1.5 as calculated with the following equation:

$$RE = \frac{W^{1.5} \times 104 \times C^{0.5}}{10^6}$$

RE = Removability Modulus

W = Unit Weight (pcf)

C = 28-day Compressive Strength (psi)

- E. The temperature of the CLSM discharged into the trench shall be below 90°F.

2.04. FLOWABLE FILL

- A. Placement Location: Flowable Fill (Larimer County Road Right of Way)
- B. Flowable fill shall be as follows unless specified otherwise in the LCRARS and the ROWCP provisions. Maximum desired 28-day strength is 60 psi.

Flowable Fill Mix	
Ingredients	Pounds/Cubic Yard
Cement	42 (0.47 sack)
Water	235 (39 gallons or as needed)
Course Aggregate (Size No. 57)	1700
Sand (ASTM C33)	1845

2.05. AGGREGATE BASE COURSE

- A. Placement Locations: Roadway Zone, Final Lift (Larimer County Road Right-of-Way)
- B. Aggregate base course shall be CDOT Class 5 or 6 unless specified otherwise per the LCRARS and the ROWCP provisions.

2.06. FOUNDATION STABILIZATION ROCK

- A. Foundation stabilization rock shall be used when the bottom of the pipe trench is saturated, soft, or otherwise unstable for providing a structural foundation for the pipe.
 - 1. An unstable trench foundation shall be observed to be wet, rutting, pumping, deflecting under foot traffic, and/or moving when equipment is used. The stability of the trench foundation shall be determined by the Construction Manager.
- B. Foundation stabilization rock shall be 2-inch minus natural rock or crushed gravel free of clay balls and organic matter, well graded, with less than 8% by weight passing the ½"-sieve unless otherwise shown on the Drawings.

2.07. FILTER FABRIC

- A. Non-woven geotextile fabric composed of polypropylene fibers having the following properties:

PROPERTY	TEST METHOD	UNITS	VALUE
Grab Tensile Strength	ASTM D4632	Lbs	120
Grab Tensile Elongation	ASTM D4632	%	50
Apparent Opening Size (AOS)	ASTM D4751	U.S. Sieve	70
Flow Rate	ASTM D4491	Gal/min/ft ²	135
Permeability	ASTM D4491	cm/sec	0.21

- B. TenCate Mirafi 140N or approved equal.

2.08. CLAY LINER

- A. Clay liner shall be Unified Soil Classification CH or CL clay material or native material modified with 8% bentonite, minimum. The clay liner thickness shall be as indicated on the Construction Drawings.

2.09. CONCRETE FOR ENCASEMENT AND CUTOFF WALLS

- A. Concrete for encasement and cutoff walls shall be Class A per Section 03 30 00, unless otherwise shown in the Drawings.

2.10. UNDERGROUND DETECTABLE WARNING TAPE

- A. See Section 33 05 26.

2.11. WATER FOR COMPACTION

- A. Water for compaction shall be free of organic materials and shall have a pH of 7.0 to 8.0, a maximum chloride concentration of 500 mg/L, and a maximum sulfate concentration of 500 mg/L.
- B. Water shall be free of organic materials injurious to the pipe coatings.

PART 3 - EXECUTION

3.01. TRENCH SLOPING, SHEETING, SHORING, AND BRACING

- A. Trenches shall have sloping, sheeting, shoring, and bracing conforming with 29CFR1926, Subpart P – Excavations, OSHA requirements.

3.02. TRENCH EXCAVATION

- A. Excavate the trench to the lines and grades shown in the Drawings with allowance for pipe thickness, sheeting, and shoring if used, and for Pipe Base. If the trench is excavated below the required grade, refill any part of the trench excavated below the grade at no additional cost to the Owner with Pipe Base material. Place the Pipe Base material over the full width of trench in compacted layers not exceeding six (6) inches deep to the required grade.
- B. Trench widths in the Pipe Zone and Initial Lifts shall be as shown in the Drawings. Comply with 29CFR Part 1926 Subpart P – Excavations. Trench width at the top of the trench will not be limited except where width of excavation would undercut adjacent structures and footings. In such case, width of trench shall be such that there are at least 2-feet between the top edge of the trench and the structure or footing.
- C. Construct trenches in rock by removing rock to a minimum of six (6) inches below the bottom of pipe and backfilling with Pipe Base material.
- D. Contractor to limit the length of open trench to not more than 250 feet in front or behind pipe currently being installed.
- E. Refer to Section 32 90 10 for wildlife crossover ramp requirements in excavated trenches.

3.03. TEMPORARY LOCATION OF EXCAVATED MATERIAL

- A. During trench excavation, place the excavated material only within the working area or within the areas shown in the Drawings. Do not obstruct any roadways. Do not place trench spoil over pipe, buried utilities, manholes, or vaults. Conform to federal, state, and local codes governing the safe loading of trenches with excavated material.
- B. Locate trench spoil piles at least 15-feet from the tops of the slopes of trenches and outside of the 100-year floodplain. Do not operate cranes and other equipment on the same side of the trench as the spoil piles.
- C. For soil management requirements refer to Section 32 90 10.

3.04. DEWATERING

- A. See Section 31 23 19.

3.05. FOUNDATION STABILIZATION

- A. The bottoms of all excavations shall be firm, stable, and shall not deform or rut under the weight of workers and equipment prior to placing any bedding, fill, or other materials in the excavation. After the required excavation has been completed, the Construction Manager will inspect the exposed subgrade to determine the need for any additional excavation. It is the intent that additional excavation be conducted in all areas within the influence of the pipeline where unacceptable materials exist at the exposed subgrade. Over-excavation shall include the removal of all such unacceptable material that exist directly beneath the pipeline to a width 24 inches greater than the pipe outside diameter and to the depth required. Where unacceptable foundation conditions are caused by Contractor's failure to dewater in accordance with the specified performance criteria, over excavation and backfilling of over excavated areas shall be performed at no additional cost to Owner.
- B. Place filter fabric on the bottom of the trench and up the sides a sufficient height to retain trench stabilization rock material. Backfill the trench to subgrade of Pipe Base with trench stabilization rock unless otherwise shown on the Drawings. Place the foundation stabilization material over the full width of the trench and compact in layers not exceeding 6 inches deep to the required grade. Once foundation stabilization material is placed up to the pipe foundation line, install filter fabric between the trench stabilization rock and the bedding.
- C. Foundation stabilization work shall only take place after approval by the Construction Manager and the Owner.
- D. Trench stabilization used by the Contractor for his convenience will not be cause for any additional payment.

3.06. INSTALLING BURIED PIPING

- A. Grade the bottom of the trench to the line and grade to which the pipe is to be laid, with allowance for pipe thickness. Remove hard spots that would prevent a uniform thickness of bedding. Place the specified thickness of pipe base material over the full width of trench. Grade the top of the pipe base ahead of the pipe laying to provide firm, continuous, uniform support along the full length of pipe and compact to the relative density specified herein. Before laying each section of the pipe, check the grade and correct any irregularities.

- B. Excavate bell holes at each joint to permit proper assembly and inspection of the entire joint. Fill the area excavated for the joints with the bedding material specified or indicated in the Drawings for use in the pipe zone. If no bedding material is specified or indicated, use imported sand bedding.
- C. Inspect each pipe and fitting before lowering the buried pipe or fitting into the trench. Inspect the interior and exterior protective coatings. Patch damaged areas in the field with material recommended by the protective coating manufacturer. Clean ends of pipe thoroughly. Remove foreign matter and dirt from inside of pipe and keep clean during and after installation.
- D. Handle pipe in such a manner as to avoid damage to the pipe. Do not drop or dump pipe into trenches under any circumstances.
- E. After pipe has been bedded, place Pipe Zone material simultaneously on both sides of the pipe, in maximum 6-inch lifts, keeping the level of backfill the same on each side. Carefully place the material around the pipe so that the pipe barrel is completely supported and no voids or uncompacted areas are left beneath the pipe. Use particular care in placing material on the underside of the pipe to prevent lateral movement during subsequent backfilling.
- F. Compact each pipe zone lift to the relative density specified herein.
- G. Carefully place Trench Zone or Intermediate Lift backfill material onto the material previously placed in the Pipe Zone or Initial Lift. Do not permit free-fall of the Trench Zone or Intermediate Lift material into the trench. Do not drop sharp, heavy pieces of material directly onto the pipe or the tamped material around the pipe. Do not operate heavy equipment or a sheepsfoot wheel mounted on a backhoe over the pipe until at least 3-feet or one-half of the internal diameter, whichever is greater, of backfill has been placed and compacted over the pipe.
- H. When the pipe laying is not in progress, including the noon hours, close the open ends of pipe. Do not allow trench water, animals, or foreign material to enter the pipe.
- I. Keep the trench dry until the pipe laying and jointing are completed.

3.07. INSTALLING NATIVE EARTH BACKFILL

- A. Native Backfill in Trench Zone – Open Areas: Thoroughly mixed native earth backfill material shall be compacted in maximum 12-inch loose lifts to the specified maximum dry density.
- B. Native Backfill in Intermediate Zone – Larimer County ROW: Thoroughly mixed native earth backfill material shall be compacted in maximum 6-inch loose lifts to the specified maximum dry density.
- C. Compact by using mechanical compaction or hand tamping. Do not use high-impact hammer-type equipment except where the pipe manufacturer warrants in writing that such use will not damage the pipe.
- D. Do not use any axle-driven or tractor-drawn compaction equipment within 5 feet of building walls, foundations, and other structures.

3.08. PLACEMENT OF CLSM OR FLOWABLE FILL

- A. Place the CLSM/FLOWABLE FILL such that it flows easily into all openings between the pipe and the excavated trench.
- B. Lay the pipe on the soil pads and place the CLSM/FLOWABLE FILL bedding as shown in the Drawings. Place bedding under pipe from one side and vibrate so that it flows under the pipe until it appears on the other side. Then add CLSM/FLOWABLE FILL to both sides of the pipe and vibrate until it completely fills the space between the pipe and the excavated trench bottom. This operation shall follow as closely behind pipe laying operations as possible. Place CLSM/FLOWABLE FILL in such a way as to prevent uplift or buckling of the pipe. Deposit CLSM/FLOWABLE FILL as nearly as practicable in its final position. Do not disturb the pipe trench or cause foreign material to become mixed with the cement slurry.
- C. Do not place backfill above the pipe until the CLSM/FLOWABLE FILL has reached the initial set. Place and maintain a 6-inch cover of moist backfill cover until additional backfill is placed. If the ambient temperature is 50°F or less, place an additional 6-inch cover of backfill over the 6-inch moist backfill cover prior to the end of the working day.
- D. Whenever freezing temperatures are imminent, maintain the CLSM/FLOWABLE FILL at a temperature of not less than 50°F for 24-hours after placement. The temperature of

the mix shall be 50°F or greater at the time of placement. Monitor the temperature by placing a thermometer in the CLSM/FLOWABLE FILL immediately after sampling at the placement site. When freezing weather appears imminent, make ready at the placement site materials that may be required for protection of the CLSM/FLOWABLE FILL. Delay placement of CLSM/FLOWABLE FILL until adequate provisions for protection against weather are made. Do not place CLSM/FLOWABLE FILL bedding in pipe trenches when the trench bottom or walls are frozen or contain frozen material. Backfill placed as cover over the CLSM/FLOWABLE FILL is prohibited from containing any frozen material.

3.09. VERTICAL TUNNEL RISER BACKFILL

- A. Vertical tunnel riser pipes shall be backfilled with native earth backfill and bedding per the Drawings. Install vertical tunnel riser backfill in the same manner as the pipe trench per Article **Error! Reference source not found..**
- B. Alternatively, vertical tunnel risers may be backfilled with CLSM per Article 2.03.

3.10. CLAY LINER PLACEMENT

- A. Clay liner shall be installed in all disturbed areas at the ditch crossing, as shown on the Construction Drawings and compacted in six (6) inch loose lifts.

3.11. DETACTABLE WARNING TAPE INSTALLATION

- A. See Section 33 05 26.

3.12. FIELD QUALITY CONTROL TESTING

- A. Backfill Compaction
 - 1. The density of soil in place shall be determined by nuclear methods, ASTM D6938. Compaction tests will be performed for each lift, layer, or area. Multiple tests in a lift or Work area may be required as deemed necessary by the Owner or Construction Manager. When additional testing is determined necessary due to a test location failing to meet the compaction requirements, testing at a greater frequency and impacts to the progress of the Work from the additional testing will not be a basis for additional compensation to Contractor.
 - 2. Determine laboratory moisture-density relations of soils by ASTM D1557 or ASTM D698. In Larimer County Road right-of-way, maximum dry density of all soil

types used shall be determined in accordance with AASHTO T99 or T180 unless specified otherwise in the LCRARS and ROWCP provisions. If nuclear methods are used for in-place density determination, the compaction test results for maximum dry density and optimum moisture content shall be adjusted in accordance with ASTM D4718. This will be required for determination of percent maximum dry density compaction and moisture variation from optimum

3. Determine the relative density of cohesionless soils by ASTM D4253 and D4254.
4. Sample backfill materials per ASTM D75.
5. "Maximum Dry Density" is the ratio, expressed as a percentage, of the in-place dry density to the laboratory maximum dry density.
6. Unless otherwise shown in the Drawings or otherwise described in the specifications for the particular type of pipe installed, compaction in pipe trenches shall be as follows:
 - a. Pipe Base, Pipe Zone, and Initial Lift: 70% relative density. One (1) compaction test every 200 LF per one (1) lift until ten (10) successful passing tests have been completed.
 - (1) Upon completion of ten (10) successful passing tests, the frequency of compaction testing may be lengthened to 300-500 LF of trench length with a minimum of one (1) test per lift on each side of the pipe, or as directed by the Construction Manager, and as long as the material remains consistent with the material sample used to determine the relative density.
 - b. Native Backfill in Trench Zone – Open Areas: Compact to a minimum of 90% of maximum dry density as determined by Standard Proctor. Moisture content $\pm$ 2% optimum. One (1) compaction test every 200 LF per one (1) lift until ten (10) successful passing tests have been completed.
 - (1) Upon completion of ten (10) successful passing tests, the frequency of compaction testing may be lengthened to 300-500 LF of trench length with a minimum of one (1) test per lift at two (2) locations per day, or as directed by the Construction Manager and as long as the backfill material remains consistent with the soil sample used to determine the maximum density.

- c. Foundation Stabilization Rock: 70% relative density.
 - d. Clay Liner: Compact to a minimum of 95% maximum dry density, Standard Proctor. Moisture content $\pm 2\%$ optimum. One (1) compaction test in the bottom of the ditch every 50 LF and one (1) compaction test every 12-inch lift (two (2) 6-inch compacted loose lifts) every 50 LF on each ditch bank.
 - e. Tunnel Riser Backfill: Compact to a minimum of 90% of maximum dry density as determined by Standard Proctor. Moisture content $\pm 2\%$ optimum. One (1) compaction test for every one (1) lift.
7. Within Larimer County Road rights-of-way, the Contractor shall perform quality control compaction testing as described below, at a minimum. Quality control compaction testing within Larimer County Road rights-of-way shall be in accordance with the LCRARS and ROWCP provisions.
- a. Intermediate Lift: Compact to a minimum of 95% maximum dry density per Standard Proctor. Moisture content $\pm 2\%$ optimum. One (1) compaction test every 100 LF per one (1) lift unless specified otherwise in accordance with the LCRARS and the ROWCP provisions.
 - b. Roadway Zone or Final Lift – Compact to a minimum of 95% maximum dry density per Modified Proctor. Moisture content $\pm 2\%$ optimum. Place in six (6) inch lifts, one (1) compaction test every 200 LF for each lift for each travel lane unless specified otherwise in accordance with the LCRARS and the ROWCP provisions.
8. Where compaction tests indicate a failure to meet the specified compaction, the Contractor will take additional tests every 25 feet in each direction until the extent of the failing area is identified. The Contractor shall rework the entire failed area until the specified compaction has been achieved at no additional cost to the Owner. Remove and replace any trenching and backfilling material that does not meet the specifications, at the Contractor's expense.

B. CLSM/Flowable Fill

- 1. The Contractor shall test all CLSM/Flowable Fill. Not less than four (4) cylinders for every 50 CY placed or fraction thereof, or as directed by the Construction Manager. Break one (1) cylinder at one (1) day, two (2) cylinders at seven (7) days and one (1) cylinder at 28 days.

C. Concrete Encasement and Cutoff Walls

1. The Contractor shall test all concrete used for concrete encasement and cutoff walls in accordance with Section 03 30 00.

END OF SECTION

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SECTION 31 41 00

SHORING

PART 1 - GENERAL

1.01. QUALITY ASSURANCE

- A. Provide surveys to monitor and document any movements of critical facilities.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Excavation Plan that details the following:
 - 1. Methods and sequencing of shoring.
 - 2. Anticipated difficulties and proposed resolutions.
 - 3. Shoring for excavations over 20 feet in depth must be designed and sealed by a Colorado-licensed Professional Engineer.

PART 2 - PRODUCTS

(NOT USED)

PART 3 - EXECUTION

3.01. GENERAL

- A. Design, provide, and maintain shoring, sheeting, and bracing as necessary to support the sides of excavations and to prevent detrimental settlement and lateral movement of existing facilities, adjacent property, and completed the Work. Comply with Occupational Safety and Health Administration (OSHA) Regulations for Underground Construction, 29 CFR Part 1926, Subpart S, Underground Construction, and Subpart P, Excavation.

3.02. REMOVAL OF EXCAVATION SUPPORT

- A. Remove excavation support in a manner that will maintain support as excavation is backfilled.

- B. Do not begin to remove excavation support until support can be removed without damage to existing facilities, completed Work, or adjacent property.
- C. Remove excavation support in a manner that does not leave voids in or reduce the compaction level of the backfill.

3.03. TRENCHES

- A. For trench excavation exceeding five (5) feet in depth, provide adequate safety system meeting requirements of applicable state and local construction safety orders, and federal requirements.

END OF SECTION

SECTION 31 41 16

SHEET PILING

PART 1 - GENERAL

1.01. REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):

- a. A36, Standard Specification for Carbon Structural Steel.
- b. A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- c. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- d. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.
- e. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
- f. A328, Standard Specification for Steel Sheet Piling.
- g. A572, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
- h. A1011/A1011M, Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.

1.02. DEFINITIONS

- A. Design Position: The location of the centroid of the pile at cutoff elevation (x, y, and z coordinates) as shown.
- B. Dynamic Monitoring: Monitoring performed with Case-Goble Pile Driving Analyzer. Gauges are attached to pile approximately 3 feet below pile head and connected with

cable to monitoring station on ground away from pile. Gauges consist of two accelerometers and two strain transducers.

- C. Elevations: Referenced to project vertical datum.
- D. Impact Stress: Stress transferred to pile head at impact from driving train, as determined from measurements using Pile Driving Analyzer.
- E. Obstruction: Sudden and significant increase of penetration resistance and deviation of pile out of tolerance resulting from encountering a subsurface or physical condition.
- F. Refusal: Penetration resistance of at least 120 blows per foot for 3 continuous feet, 200 blows per foot for 1 foot, or 50 blows per inch for 2 consecutive inches, whichever comes first, and to continue driving pile would be impractical. These criteria apply only for hammer sizes and operation as specified.
- G. Rated Hammer Energy:
 - 1. Diesel Hammers: Product of rated stroke times ram weight.
 - 2. Air Hammers: Rated energy from manufacturer's literature.
- H. Restriking: Positioning driving train and driving already installed pile after some nominal waiting period (as specified) after initial installation. This definition applies to redriving piles selected by Engineer for determining appropriate driving criteria requirements or for checking pile integrity. Restriking may require mobilizing crane and driving train from one pile to another location at opposite ends of structure(s).
- I. Set: Pile penetration in inches per blow.
- J. Sweep: Deviation from straightness measured along two perpendicular faces of pile while not subject to bending forces.
- K. Termination Penetration Resistance: Penetration resistance exceeding 60 blows per foot at which driving may be terminated.
- L. Transferred Hammer Energy: Energy transferred to pile head from driving train impact, as determined from measurements using Pile Driving Analyzer.

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00:

1. Indicate number of piles required, fabricated corners, and detail dimensions.
2. Manufacturer's product data prior to ordering piles.
3. Pile driving schedule.
4. Written sequence of setting and driving operation.
5. Drilling:
 - a. Manufacturer's literature on equipment and operation procedures.
6. Hammers:
 - a. Manufacturer's specifications and catalog information. Show data necessary for computing bearing value of piles driven.
7. Installer Qualifications.
8. Daily Log and Record:
 - a. At end of each working day, submit two copies of each record for every pile constructed that day.

1.04. QUALIFICATIONS

- A. Piling Installer: Minimum of 5 years of past successful experience on ten projects of sheet pile installation.

1.05. DELIVERY, STORAGE, AND HANDLING

- A. Sheet Piles: Lift and handle so that maximum bending stresses shall not exceed 22,500 pounds per square inch.

1.06. SPECIAL TOOLS

- A. Tool checking interlock dimensions.

PART 2 - PRODUCTS

2.01. SHEET PILES

- A. Minimum size and wall thickness shown manufactured to ASTM A36, ASTM A1011/A1011M, and ASTM A572.
- B. Sections: Continuously interlocking type, structural characteristics as shown in contractor design.
- C. Section Modulus: Base on individual whole piece, not dependent on the interlock friction between pile sections to secure the required section modulus.
- D. Stamp mill heat number on each pile.
- E. Pulling (Handling) Holes: Manufacturer's standard, additional will not be allowed.
- F. Tolerances: Weight per square foot may not vary by more than 2-1/2 percent over or under that specified.

2.02. ACCESSORIES

- A. Tie Rod Assembly: Adjust spacing, size, plate dimensions, and length of tie rods if piling sections are of different proportions.

1. Tie Rods:

- a. Fabricated Steel: ASTM A36, upset ends, threaded American Standard Free Fit, Class 2.
- b. Coat with grease and wrap for protection from rust and physical damage while in transit.

2. Turnbuckles:

- a. Forged steel with American Standard Class 2 fit threads, takeup, and other dimensions as shown in American Institute of Steel Construction, Manual of Steel Construction.
- b. Finished, with parts properly shaped and free from fins, cracks, flaws, seams, and other injurious defects.
- c. Screw Threads: True to form, clean cut, and free from injurious defects.

d. Nuts: Standard hexagon, American Standard Class 2 fit threads.

B. Steel Shapes, Plates, Bars, and Washers:

1. General: ASTM A36, provide cut washers for each bolt head and nut.
2. Bolts: ASTM A307, of length to finish 1/4 inch outside the nut and have additional thread to retighten.
3. Boat Spikes: 3/8-inch.
4. Hardware: Hot-dip galvanized, per ASTM A123.

PART 3 - EXECUTION

3.01. DRIVING EQUIPMENT

A. Air or Steam Hammer: Minimum manufacturer's rated capacity of 24,000 foot-pounds of energy per blow.

1. Pressure Gauge: Locate near hammer for measuring air or steam pressure.

B. Diesel Hammers:

1. Ram Weight: Not less than 3,600 pounds.
2. Energy Developed: Exceed 13,000 foot-pounds per blow.

C. Sonic Hammers: Use of adequate size and type. Demonstrate capability prior to approval for pile driving.

D. Vibratory Driver-Extractor Characteristics:

Eccentric moment	3,400 inch-pounds
Frequency of vibration	700 to 1,020 vpm
Amplitude	5/16" to 1"
Horsepower	100 (minimum)

1. Transmission Case: Effectively isolated from suspension system by pneumatic or other means so that the unit has lateral stability during the driving operation.

3.02. PILE LENGTHS

- A. Lengths shown are those required below cutoff. Furnish sheet piling with sufficient extra length to provide for fresh heading and to reach from the cutoff elevation up to position of driving equipment.

3.03. DRIVING GUIDES

- A. Position sheet piles using temporary guide wales support and anchor guide wales to form rigid structures during the sheet pile setting and driving operation.
- B. Guide Wales: Stationary (not moveable) with fluctuating water stage.

3.04. SETTING

- A. Clean pile; inspect for defects and proper interlock dimensions.
- B. Allow pile sufficient clearance in the interlocks to slide, under its own weight, in the interlock of the sheet pile previously placed until the top of existing ground is reached by the tip of the sliding pile. Do not use vibratory or drive hammer to force the interlocking of piles.

3.05. DRIVING

- A. Before driving is started, check sheet piles for position and alignment. Locate pile top within 2 inches of location shown.
- B. Drive sheet piles to the tip elevations shown. Drive down piles that are raised during the process of driving adjacent piles.
- C. If refusal is reached before driving to the specified tip elevation, an impact hammer or controlled jetting may be used. Perform jetting on both sides of sheet pile simultaneously with driving.
- D. Remove and replace sheet pile driven out of interlock.
- E. Driving Tolerances: Not more than 1/8-inch per foot from the vertical in all directions. Furnish plumb line or other device for checking vertical alignment. Not more than one percent from vertical or two percent from batter shown.

3.06. PILE CUTOFF

- A. Cut square at required elevation with tools that will not damage area below cut surface.
- B. Tolerance: Plus or minus 1/2 inch.

3.07. CUTTING AND SPLICING PILES

- A. Extend to required grade by welding on additional full-length piles driven below grade, and piles with damaged heads which have been cut off to permit further driving.
- B. Pile Splicing: Butt weld, making full penetration of the web. Piles adjoining spliced piles shall be full length piles.

3.08. WALES AND CAPS

- A. After driving sheet piling, install channel wales. Bolt splices in wales with field bolts. Set wales horizontal.
- B. Installation:
 - 1. Weld Splices using a single bevel butt joint, welded on one side on backing structure.
 - 2. Space wales within 1/4 inch for welded splices. Fabricate accessories by welding or as otherwise shown.

3.09. TIE ROD ASSEMBLIES

- A. Installation:
 - 1. Hand backfill tie rods to 6 inch depth above rods.
 - 2. Support tie rods in straight line from bulkhead to anchor wall.
 - 3. Maintain tie rod support until rod is tensioned.
- B. Use sandfill or wood cribbing to maintain tie rod alignment.
- C. Tension tie rods with turnbuckles in Engineer's presence. Lubricate turnbuckles with graphite prior to tensioning.

3.10. TIE ROD HOLES

- A. Neatly cut through sheet piles by mechanical means. Flame cutting shall not be used.
- B. Spacing may vary up to 4 inches to avoid cutting sheet pile interlocks.
- C. Variations in Spacing: Prevent an accumulative variation of more than 4 inches.

3.11. FIELD QUALITY CONTROL

- A. Daily Log and Record: Document for each sheet pile driven, showing as a minimum:
 - 1. Pile identification/location.
 - 2. Weather/groundwater conditions.
 - 3. Date and time start and complete driving.
 - 4. Respective depths of penetration.
 - 5. Cutoff elevations.
 - 6. Driving resistance for each foot of driving over entire pile length.
 - 7. Equipment used.
 - 8. Installation method.
 - 9. Final pile head position (x, y, z coordinates) after cut off indicating if pile is installed within the specified tolerances.
 - 10. Nature and location of obstructions encountered.
 - 11. Other pertinent pile driving behavior.

END OF SECTION

SECTION 31 71 10

TRENCHLESS INSTALLATION BY GUIDED AUGER BORING

PART 1 - GENERAL

1.01. DESCRIPTION:

- A. This section includes the requirements for the installation of Casing Pipe using guided auger boring methods.
- B. The Scope of Work to be performed under this section includes:
 - 1. Designing, detailing, fabricating, and installing Casing Pipe by guided auger boring methods as shown on the Contract Drawings and to the line and grade tolerances specified herein.
 - 2. Labor, material, tools, equipment, and incidentals necessary to complete the work described above.
 - 3. Spoil hauling and disposal.
- C. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements. The Contractor shall select and utilize methods and equipment compatible with the dimensions of the tunnels shown and with anticipated geologic conditions described in the Geotechnical Baseline Report (GBR).

1.02. REFERENCES:

- A. Geotechnical Reports
 - 1. Report dated April 17, 2026, prepared by Brierley Associates entitled "Geotechnical Baseline Report, Thornton Water Project – Segment F.1"
 - 2. Report dated July 15, 2026, prepared by CMT entitled "Geotechnical Data Report, Thornton Water Project – Segment F.1"
- B. Applicable Standards:
 - 1. Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Subpart S (Underground Construction)

2. American National Standards Institute (ANSI) / American Association of State Highway and Transportation Officials (AASHTO) / American Welding Society (AWS) D1.1 - Structural Welding Code.
3. ASTM A1097 Standard Specification for Steel Casing Pipe, Electric-Fusion (Arc)-Welded.
4. American Water Works Association (AWWA) C200 Steel Water Pipe
5. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1.03. DEFINITIONS:

- A. Guided Auger Boring: The trenchless installation utilizing a pilot tube or steerable head where the auger string is placed within the steel casing, which is advanced with jacks in the shaft at the back of the pipe string. Spoil is excavated by helical auger flights rotating in a steel Casing Pipe.
- B. Pilot Tube: Small diameter pipe pushed and/or drilled into the ground with directional control and tight tolerances used as a pilot hole for larger trenchless installations.
- C. Carrier Pipe: Pipe that carries the product material.
- D. Casing Pipe: The steel pipe jacked forward to provide ground support during tunneling.
- E. Excavation Line: The outer limit of tunnel excavation.
- F. Face: The location where excavation takes place; the head of the tunnel excavation; typically vertical or near vertical.
- G. Jacking Frame: A structural component in the launching shaft, fitted with hydraulic cylinders, which is used to push the cutting head and Jacking Pipe string into the ground for pipe jacking methods. The Jacking Frame serves to distribute the thrust load to the pipe string and the reaction load to the Thrust Block.
- H. Overcut: The difference between the radius of the outside of the reaming head or cutting shoe as appropriate, and the outside of the Jacking Pipe.
- I. Thrust Block: An engineered structure located between the Jacking Frame and the launch shaft wall to transfer the jacking force through the shaft support into the ground.

- J. Two Pass Tunneling System: A method of trenchless excavation in which Casing Pipe is installed prior to installation of the Carrier Pipe.
- K. Settlement Trough: Width of zone above tunnel that is affected by settlement from trenchless excavations.

1.04. QUALIFICATIONS:

- A. The Tunnel Contractor shall have a minimum of five years of experience on pipe jacking projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.
- B. The Tunnel Superintendent shall have a minimum of ten years of civil construction experience with at least five years supervisory field experience on guided auger boring projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.
- C. The Tunnel Operator shall have a minimum of five years of experience on guided auger boring projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.
- D. Project control must be set by a Surveyor licensed by the State of Colorado and have at least five years' experience in surveying.
- E. Welders shall be qualified under the provisions of AWS D1.1.

1.05. SUBMITTALS:

- A. Submit in accordance with Section 01 33 00.
- B. At least 90 days prior to the starts of work, all submittals, including drawings and calculations, shall be required for the sole purpose of providing Engineer sufficient details to confirm that the Contractor planned work and work in progress is in accordance with Contract Documents. Engineer's review shall not be construed to relieve Contractor in any way of responsibilities under the Contract. Do not begin work on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer.
- C. Preconstruction. Submit the following qualifications:
 - 1. The name and qualifications of the Tunnel Contractor.

2. The name and qualifications of the Tunnel Superintendent.
 3. The name and qualifications of the Tunnel Operator.
 4. The name and certifications of the welders.
- D. Preconstruction: Submit a Tunnel Work Plan, including the following:
1. A detailed description of the tunneling equipment and procedures to be employed. Provide manufacturer's literature describing tunneling system in detail including machine type, any design modifications, spoils removal system, guidance system, and provisions for injecting pipe lubricants.
 2. Description of tunnel excavation equipment to be used including: original manufacturer; model or type; drawings and dimensions of equipment configuration; method of face excavation; face control capability; amount of overcut; propulsion system, and layout of excavation and ancillary equipment for the tunnel.
 3. Details of the Casing Pipe to be used indicating pipe wall thickness, joint details. Indicate the required fabrication tolerances to prevent damage to the pipe during installation, and provide a certification from the pipe manufacturer indicating that the Casing Pipe is designed adequately for the project requirements and will perform acceptably.
 4. Design calculations demonstrating the proposed Casing Pipe is capable of supporting the maximum stresses to be imposed on the pipe during handling and jacking. The calculations should take into account the maximum: ground and hydrostatic loads, jacking forces, external loads such as live loads due to traffic/railroad, and any other loads. The calculations shall include design for allowable deflection and buckling. Calculations shall be prepared, stamped, and signed by a Professional Engineer registered in the State of Colorado.
 5. Details of pipe lubrication injection system and pipe lubricants used during tunneling including Manufacturer's literature.
 6. Method of controlling line and grade of the tunnel including a description of the alignment control and steering systems. Provide manufacturer's literature and drawings showing set up and support provisions.

7. Procedures for measuring excavation quantities versus forward progress during the tunneling operation.
8. Settlement Calculations: The Contractor shall provide calculations that estimate the dimensions of the settlement trough. All calculations shall be signed and sealed by a licensed State of Colorado Professional Engineer.
9. Schedule of advance indicating the anticipated start and end dates, startup and completion periods, and rate of advance for different phases of tunneling.
10. Schedule. A critical path schedule of tunneling-related activities and activities for project components interfacing with the tunnel indicating the anticipated start and end dates, startup and completion periods. Include as a minimum the following activities: mobilization, equipment setup, tunneling, contact grouting, site restoration, demobilization, and cleanup. Include number of working days per week, shifts per day, and hours per shift.
11. A general Contingency Plan, procedures, and details for completing the tunnel in the event each of the following scenarios:
 - a. Scenario 1 – Strong hydrocarbon smell is detected in the spoils.
 - b. Scenario 2 – The tunnel advance encounters a hard obstruction. Provide contingencies for each case when the obstruction is equal to or less than $\frac{1}{3}$ the tunnel diameter and greater than $\frac{1}{3}$ the tunnel diameter, taking into consideration surface access issues.
 - c. Scenario 3 – The tunnel encounters a fibrous obstruction such as timber, taking into consideration surface access issues.
 - d. Scenario 4 – Settlement is detected near a road or railroad crossing during tunneling operations.
 - e. Scenario 5 – High jacking loads cause damage to the Casing Pipe or stop advancement of the tunnel.
12. Contractor's safety plan for personnel conducting tunneling operations including provisions for ventilation, temperature control, lighting, electrical safeguards, safety of the public, monitoring, and warning systems. Submit a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.

- E. Construction. Submit the following during construction within the specified time restrictions:
 - 1. Written Daily Logs as specified herein. The Daily Logs shall have field logs recorded for each shift and shall be submitted to the Engineer within one working day of excavation at each location.
- F. Post-Construction.
 - 1. As-built drawings for each tunnel shall be submitted to the Project Manager within two weeks of completion.
 - 2. Submit Casing Pipe survey results within 24 hours of measurement.

PART 2 - PRODUCTS

2.01. MATERIALS:

- A. Casing Pipe shall be specifically designed for tunneling as appropriate. Where appropriate, The pipe shall be designed to carry Cooper E-80 Railroad or AASHTO HL-93 live loading. The Casing Pipe shall be in accordance with the pipe manufacturer's specifications and guidelines for jacking as appropriate. The contractor shall adhere to pipe manufacturer's installation guidelines for: 1) handling, 2) launch shaft or pit preparations, 3) end preparations, mating procedures, and installation, and 4) special applications. Casing pipes shall be capable of withstanding the jacking forces imposed during installation, and the final in-place loading conditions. The ends of the Casing Pipe shall be protected against damage during installation.
- B. Steel Casing Pipe shall be smooth wall welded steel cylinder fabricated in accordance with ASTM A1097, having a minimum yield strength of 36,000 pounds per square inch. The Casing Pipe shall be fabricated in accordance with these standards unless the Contractor determines that tighter tolerances are required to avoid damage to the pipe during installation to successfully complete the tunnel drive lengths.
- C. The smallest inside diameter of the Casing Pipe shall be a minimum of 12 in. larger than the largest outside diameter of the Carrier Pipe.
- D. Casing Pipe joints shall be butt-welded around the entire joint perimeter to produce a watertight seal in accordance with AWS D1.1 Welds shall be of a size to develop the full

strength of the pipe materials. Proprietary non-welded steel joints such as Tri-Loc or Permalok shall be installed in accordance with manufacturer's specifications.

- E. The Casing Pipe shall be provided with ports for injection of grout. Maximum port spacing and orientation of hole locations shall be shown on the Contract Drawings. The ports shall be supplied with threaded port plugs. Port plugs shall be manufactured by the pipe manufacturer and shall be compatible with the pipe.

2.02. EQUIPMENT:

- A. The Contractor shall determine and provide the equipment necessary for the trenchless excavation and the installation of the Casing Pipe and complete all work associated with this section.
- B. The Overcut shall not exceed one inch.
- C. Utilize a spoil transportation system that has the capacity for removal of spoil in balance with excavation and pipe advance. Spoil transportation and disposal, hoisting, lifting, safety and control equipment shall be compliant with applicable local codes and standards.
- D. As applicable, soil removal methods shall incorporate use of a hole opener, casing, and augers such that the total system facilitates safe and controlled excavation of the advancing face at all times.
- E. Incorporate a device for providing a display of the elevation datum for the drive.

PART 3 - EXECUTION

3.01. GENERAL:

- A. Perform all work in the presence of the Owner's Representative, unless the Representative has granted prior approval in writing to perform such work in his/her absence.
- B. The Contractor shall give the Engineer a minimum of ten days advance notice of the start of work.
- C. Design, install and operate trenchless excavation support utilities as necessary for support of construction and the safety of workers in accordance with project requirements and all Federal, State, and local laws, regulations, and codes.

- D. The equipment and methods the Contractor employs to perform the work shall be appropriate for the conditions set forth in the GBR.
- E. Do not begin tunneling until:
 - 1. Required submittals have been made and the Engineer has reviewed and accepted submittals.
 - 2. All required permits are in place and the governing agencies have been satisfactorily notified of the schedule and work.
 - 3. Shaft/pit excavations, stabilization and shoring have been satisfactorily completed in accordance with Section 31 75 00, Shaft Excavation and Support.
 - 4. All monitoring and instrumentation points have been established and baseline measurements have been obtained per Section 31 09 13 Geotechnical Instrumentation and Monitoring.
 - 5. A pre-job safety conference has been conducted. Arrange this conference and inform the Engineer of the time and place of the conference at least seven days in advance of the tunnel construction.
- F. Maintain clean working conditions at all times.
- G. The Contractor shall have the sole responsibility for maintenance and protection of existing utilities, railroad tracks, structures, and facilities within the estimated settlement trough zone. Location of utilities shown on the Construction Drawings shall be considered approximate. The Contractor shall be responsible for locating each utility potentially impacted by the work to verify location prior to beginning the tunneling work.

3.02. SAFETY REQUIREMENTS:

- A. Methods of construction shall be such as to ensure the safety of the workers, project participants, the public, third parties, and adjacent property, whether public or private. The Contractor is solely and completely responsible for maintaining safe working conditions at the site at all times.
- B. Perform all work in accordance with the current applicable regulations of the Federal, State, and local agencies. In the event of conflict, comply with the more restrictive applicable requirements.

3.03. TUNNEL EXCAVATION:

A. Pilot Tube Installation

1. Each Pilot Tube Auger Bore (PTAB) shall begin with jacking (advancement) of a hollow pilot tube rod system with a directional head, used to control alignment of the pilot tubes. Monitor line and grade continuously during pilot tube guided auger boring operations. Record deviation with respect to design line and grade at least once per foot and submit records to Engineer as requested. Once pilot tube jacking is started, the work shall progress continuously without interruption until the pilot tube reaches the receiving pit.
2. Once the pilot tube reaches the receiving pit, the hole shall be enlarged as needed using a hole opener attached to steel drill casing, equipped with internal augers, which shall be jacked behind the pilot tube. Soil volumes removed from the hole will be recorded and reported to the Owner's representative.

B. On-Target Steering System Installation

1. Each On-Target Auger Bore shall begin with the advancement of the lead steel casing equipped with a specialized hydraulic steering head. The steering head shall be the same diameter as the product casing and shall be capable of independent horizontal and vertical navigation via four hydraulically actuated steering flaps.
2. Monitor line and grade continuously using a line-of-sight laser or twin-light halogen alignment system and a vertical water-level sensor. Deviation from the design path shall be recorded at least once per 5 feet and submitted to the Engineer upon request.
3. Soil shall be removed from the face of the steering head using an auger string rotating within the casing. The steering head shall be equipped with a specialized "cutting head" that allows for the controlled intake of soil. The Contractor shall monitor the volume of soil removed versus the displacement volume of the casing to prevent over-excavation or subsidence.

- C. The Contractor is responsible to immediately repair any damages within the estimated settlement trough zone. Damages shall be repaired before the Contractor demobilizes from the site. Repairs shall be performed at no cost to the Owner.

- D. Avoid damage to pipe sections and joints during jacking. In the event of damage to a pipe section or pipe joint, the Contractor shall notify the Engineer within the day of observation of the damage. If the damage is within the shaft, the Contractor shall remove the damaged section of pipe in a manner to allow welding of an undamaged pipe.
- E. All welding shall be done in accordance with AWS D1.1.
- F. The Contractor shall design a lubrication system outside and/or inside the pipe suitable for the soil conditions described in the GBR. If lubrication is used, the Contractor shall at all times monitor the volumes, pressures, and location of lubricant pumping to ensure that the annulus around the pipe is completely filled with lubricant.
- G. The contractor may employ 24-hour operations, if they deem necessary for successful tunnel installation.

3.04. EXCAVATED MATERIALS:

- A. The Contractor will dispose of excavated materials. Spoils disposal shall be the responsibility of the Contractor. Provide written documentation from the disposal site(s) indicating that they will accept the spoils and are in compliance with applicable regulations

3.05. CONTROL OF LINE AND GRADE:

- A. The Casing Pipe shall be installed within an accuracy of +/- 1 inch of accuracy to the alignment and elevation shown on the Contract Drawings.
- B. The Contractor is responsible for setting control points, and controlling the line and grade of the tunnel as necessary to achieve the specified line, grade and tolerances for the Carrier Pipe.
- C. If the Casing Pipe is off line and/or grade by more than the specified tolerances, the Contractor shall make adjustments, repairs and changes as necessary to achieve the specified tolerances.
- D. If the tunnel is sufficiently far off line and/or grade to require redesign of structures, acquisition of easements, or backfilling and re-excavation, the Contractor shall be responsible for doing all additional work and costs.

- E. Steering corrections made to the tunnel alignment, if applicable, shall be carried out in such a manner that the joint angle of any two adjacent pipes or segments does not exceed allowable limits, and at a rate of not more than 1 in. per 25 ft.
- F. Verification Survey. Survey and submit exact position of TBM and installed Jacking Pipe during tunneling to ensure alignment is within specified tolerances, independent of the guidance system. Independent surveys shall be performed every 100 ft of tunnel advance or more frequently. Verification survey shall include survey of each Jacking Pipe joint installed.

3.06. TUNNEL ACCESS:

- A. The Contractor shall allow access to the Engineer and shall furnish necessary assistance and cooperation to aid the Engineer in observations, measurements, data, and sample collection, including, but not limited to the following:
 - 1. The Owner and/or Engineer shall have full access to the operator control area prior to, during, and following all PTAB operations. This shall include, but not be limited to, providing visual access to real-time operator control screens, gauges, and indicators.
 - 2. The Owner and/or Engineer shall have full access to the launching and receiving pits prior to, during, and following all jacking operations. This shall include, but not be limited to, visual inspection of installed pipes, launch and retrieval seals, and verification of line and grade. The Contractor shall provide safe access in accordance with all safety regulations.
 - 3. The Engineer shall be allowed to collect spoil samples.

3.07. TUNNELING RECORDS:

- A. Contractor shall maintain Daily Shift Reports for all components and phases of tunnel excavation. The Shift Reports shall be signed by the Tunnel Superintendent and shall contain the following:
 - 1. Work crews and equipment onsite, and the work performed. The reports shall be broken down into work time and down/standby time for each crew and piece of equipment;
 - 2. Progress made for each construction stage;

3. Survey results – line and grade;
 4. Problems or unusual conditions encountered and actions taken to address these situations;
 5. Start and finish time of advancement for each pipe section;
 6. Total distance jacked at the end of each day;
 7. Volume and placement location of lubrication, if used;
 8. General description of each discernible ground condition mined;
- B. Contractor shall maintain records of all surveys.
- C. Contractor shall maintain records of tunnel excavation including but not limited to the following:
1. The station of the face of the excavation and advance distance.
 2. The date, starting time, and finish time.
 3. Any unusual conditions, breakdowns, and delays.
- D. As-built drawings for each tunnel shall be submitted and accepted by the Engineer prior to recommending final payment.
- 3.08. CLEANUP AND RESTORATION:
- A. Remove all equipment, unused materials, and debris from the site at the end of the job. Restoration shall follow construction as the work progresses and shall be completed as soon as possible. Restore and repair any damage resulting from surface settlement caused by the work. Any property or improvements damaged or destroyed, shall be restored to a condition equal to or better than existing prior to construction at no additional cost to the Owner. Restoration shall be completed immediately if a third party or the Owner are inconvenienced by the damage, and in no case later than 30 days after the damage is discovered. This provision for restoration shall include all property which was affected by the construction operations.
- B. At the end of every construction day, construction equipment and materials shall be removed as far from operating railroad tracks as possible (minimum 25 ft from centerline).

END OF SECTION

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SECTION 31 71 30

TRENCHLESS INSTALLATION BY TUNNEL BORING MACHINE

PART 1 - GENERAL

1.01. DESCRIPTION:

- A. This section includes the requirements for tunnel excavation and the installation of Casing Pipe with a Tunnel Boring Machine.
- B. The Scope of Work to be performed under this section includes:
 - 1. Designing, detailing, fabricating, and installing Jacking Pipe by Tunnel Boring Machine as shown on the Contract Drawings and to the line and grade tolerances specified herein.
 - 2. Labor, material, tools, equipment, and incidentals necessary to complete the work described above.
 - 3. Spoil hauling and disposal.
- C. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements. The Contractor shall select and utilize methods and equipment compatible with the dimensions of the tunnels shown and with anticipated geologic conditions described in the Geotechnical Baseline Report (GBR).
- D. The following Jacking Pipes are approved for the tunnels on this project:
 - 1. Steel

1.02. REFERENCES:

- A. Geotechnical Reports
 - 1. Report dated April 17, 2026, prepared by Brierley Associates entitled "Geotechnical Baseline Report, Thornton Water Project – Segment F.1"
 - 2. Report dated July 15, 2026, prepared by CMT entitled "Geotechnical Data Report, Thornton Water Project – Segment F.1"

B. Applicable Standards:

1. Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Subpart S (Underground Construction)
2. American National Standards Institute (ANSI) / American Association of State Highway and Transportation Officials (AASHTO) / American Welding Society (AWS) D1.1 - Structural Welding Code.
3. ASTM A1097 Standard Specification for Steel Casing Pipe, Electric-Fusion (Arc)-Welded.
4. American Railway Engineering and Maintenance-of-Way Association (AREMA).

1.03. DEFINITIONS:

- A. Carrier Pipe: Pipe that carries the product material.
- B. Face: The location where excavation takes place; the head of the tunnel excavation; typically vertical or near vertical.
- C. Intermediate Jacking Station: Series of hydraulic jacks spaced around Jacking Pipe circumference and temporarily installed between two Jacking Pipe segments inside a steel casing fabricated to the same outside diameter as the Jacking Pipe.
- D. Lubricant: Bentonite suspension used to fill and pressurize the annular space between the TBM and ground and between the Jacking Pipe and ground.
- E. Jacking Frame: A structural component in the launching shaft, fitted with hydraulic cylinders, which is used to push the cutting head and Jacking Pipe string into the ground for pipe jacking methods. The Jacking Frame serves to distribute the thrust load to the pipe string and the reaction load to the Thrust Block.
- F. Jacking Pipe: The pipe jacked behind the boring machine to provide ground support during tunneling and to act as the Casing Pipe in two-pass installations.
- G. Tunnel Boring Machine (TBM): An open-face, steerable, laser-guided, articulated shield with rotating cutter head for excavating the ground which is operated from inside the machine.
- H. Overcut: The difference between the radius of the outside of the TBM cutters, and the outside of the Jacking Pipe or TBM.

- I. Thrust Block: An engineered structure located between the Jacking Frame and the launch shaft wall to transfer the jacking force through the shaft support into the ground.
- J. Settlement Trough: Width of zone above tunnel that is affected by settlement from trenchless excavations.

1.04. QUALIFICATIONS:

- A. The Tunnel Contractor shall have a minimum of five years of experience on pipe jacking projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.
- B. The Tunnel Superintendent shall have a minimum of ten years of civil construction experience with at least five years supervisory field experience on tunneling projects on pipe jacking projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.
- C. The Tunnel Operator shall have a minimum of five years of experience on pipe jacking projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.
- D. Project control points must be set by a Surveyor licensed by the State of Colorado and have at least five years' experience in underground surveying.
- E. Design of engineered structures as defined herein shall be signed and sealed by a Registered Professional Engineer in the State of Colorado with a minimum of five years of experience in structural design of tunnels and/or shafts as appropriate.
- F. Welders shall be qualified under the provisions of AWS D1.1.

1.05. SUBMITTALS:

- A. Submit in accordance with Section 01 33 00.
- B. At least 90 days prior to the start of work, all submittals, including drawings and calculations, shall be required for the sole purpose of providing Engineer sufficient details to confirm that the Contractor planned work and work in progress is in accordance with Contract Documents. Engineer's review shall not be construed to relieve Contractor in any way of responsibilities under the Contract. Do not begin work

on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer.

C. Preconstruction. Submit the following qualifications:

1. The name and qualifications of the Tunnel Contractor.
2. The name and qualifications of the Tunnel Superintendent.
3. The name and qualifications of the Tunnel Operator.
4. The name and qualification of the Tunnel Surveyor.
5. The name and certifications of the welders.

D. Preconstruction: Submit a Tunnel Work Plan, including the following:

1. A detailed description of the tunneling equipment and procedures to be employed. Provide manufacturer's literature describing tunneling system in detail including machine type, any design modifications, spoils removal system, guidance system, and provisions for injecting pipe lubricants.
2. Letter from the tunnel boring machine manufacturer certifying that the proposed machine has been inspected by qualified mechanics and found free of defects or mechanical deficiencies prior to construction.
3. Detailed drawings and dimensions of equipment configuration; amount of overcut; propulsion system, and layout of excavation and ancillary equipment for the tunnel.
4. Jacking equipment including: manufacturer; drawings and dimensions of equipment configuration; jack arrangement; capacity; and thrust ring design. If used, submit Jacking Frame and Thrust Block shop drawings and calculations stamped by a Professional Engineer registered in the State of Colorado. Demonstrate that the anticipated jacking forces are coordinated with the shoring design.
5. Capacity, number, and arrangement of main jacks, provide details of thrust ring, jacking controls and pressure gages. Provide an estimate of the maximum jacking force expected. Include locations, jack arrangement, capacity, jack interface with pipe, and method of closure for intermediate jacking stations, if used.

6. For Jacking Pipe, indicate pipe wall thickness and joint details. Indicate the required fabrication tolerances to prevent damage to the pipe during installation and provide a certification from the pipe manufacturer indicating that the Jacking Pipe is designed adequately for the project requirements and will perform acceptably.
7. Design calculations demonstrating the proposed Jacking Pipe is capable of supporting the maximum stresses to be imposed during tunneling. The calculations should take into account the maximum: ground and hydrostatic loads, jacking forces, external loads such as live loads due to traffic/railroad, and any other loads. The calculations shall include design for allowable deflection and buckling. Calculations shall be prepared, sealed, and signed by a Professional Engineer registered in the State of Colorado.
8. If used, details of lubrication injection system and lubricant used during tunneling including Manufacturer's literature.
9. A description of the guidance and steering systems. Provide manufacturer's literature, drawings showing set up and support provisions, and other details for alignment control. Submit a description of independent surveying methods during construction. Confirm that systems can achieve required line and grade within specified tolerances.
10. Procedures for measuring excavation quantities versus forward progress during the tunneling operation.
11. Settlement Calculations: The Contractor shall provide calculations that estimate the dimensions of the settlement trough. All calculations shall be signed and sealed by a licensed State of Colorado Professional Engineer.
12. Spoil, separation, transport, and disposal equipment and procedures including the location of spoil disposal sites.
13. Plan for personnel conducting tunneling operations including provisions for ventilation, temperature control, lighting, electrical safeguards, safety of the public, monitoring, and warning systems.
14. Schedule. A critical path schedule of tunneling-related activities and activities for project components interfacing with the tunnel indicating the anticipated start and end dates, startup and completion periods. Include as a minimum the

following activities: mobilization, jacking equipment setup, tunneling, contact grouting, site restoration, demobilization, and cleanup. Include number of working days per week, shifts per day, and hours per shift.

15. A general Contingency Plan, procedures, and details for completing the tunnel in the event any of the following scenarios.
 - a. Scenario 1 – Strong hydrocarbon smell is detected in the spoils.
 - b. Scenario 2 – The tunnel advance encounters a hard obstruction. Provide contingencies for each case when the obstruction is equal to or less than $\frac{1}{3}$ the tunnel diameter and greater than $\frac{1}{3}$ the tunnel diameter, taking into consideration surface access issues.
 - c. Scenario 4 – A blowout or spill of lubrication or grout occurs at the ground surface.
 - d. Scenario 5 – Settlement is detected near a road or railroad crossing during tunneling operations.
 - e. Scenario 6 – High jacking loads cause damage to the Jacking Pipe or stop advancement of the tunnel.
 - f. Scenario 7 – A major mechanical breakdown or equipment failure.
 - g. Scenario 8 – The target laser is distorted by heat and/or humidity in the tunnel or the target laser is knocked out of alignment.
 - h. Scenario 9 – Soil conditions cause the tunnel to deviate from line and grade or result in excessive settlement.
 16. Contractor's safety plan for personnel conducting tunneling operations including provisions for ventilation, temperature control, lighting, electrical safeguards, safety of the public, monitoring, and warning systems. Submit a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.
- E. Construction. Submit the following during construction within the specified time restrictions:

1. Written Daily Logs as specified herein. The Daily Logs shall be submitted to the Engineer within one working day of excavation at each location

F. Post-Construction:

1. Submit survey results within 24 hours of measurement.
2. As-built drawings for each tunnel shall be submitted to the Engineer within two weeks of completion.

PART 2 - PRODUCTS

2.01. JACKING PIPE:

- A. Jacking Pipe shall be specifically designed for tunneling as appropriate. Where appropriate, the pipe shall be designed to carry Cooper E-80 Railroad or AASHTO HL-93 live loading. The Jacking Pipe shall be in accordance with the pipe manufacturer's specifications and guidelines for jacking as appropriate. The contractor shall adhere to pipe manufacturer's installation guidelines for: 1) handling, 2) launch shaft or pit preparations, 3) end preparations, mating procedures, and installation, and 4) special applications. Jacking pipes shall be capable of withstanding the jacking forces imposed during installation, and the final in-place loading conditions. All loads shall be shown on the submitted calculations and described. Include assumed maximum drive length. The calculations shall include design for allowable deflection and buckling. All calculations shall be signed and sealed by a licensed State of Colorado Professional Engineer.
- B. Steel Jacking Pipe shall be smooth wall welded steel cylinder fabricated in accordance with ASTM A1097, having a minimum yield strength of 36,000 pounds per square inch. The Jacking Pipe shall be fabricated in accordance with these standards unless the Contractor determines that tighter tolerances are required to avoid damage to the pipe during installation to successfully complete the tunnel drive lengths.
- C. The smallest inside diameter of the Jacking Pipe shall be a minimum of 12 in. larger than the largest outside diameter of the Carrier Pipe.
- D. Welded Jacking Pipe joints shall be butt-welded around the entire joint perimeter to produce a watertight seal in accordance with AWS D1.1. Welds shall be of a size to develop the full strength of the pipe materials. Proprietary non-welded steel joints

such as Tri-Loc or Permalok shall be installed in accordance with manufacturer's specifications.

- E. The Jacking Pipe shall be provided with ports for injection of lubricant and grout. Maximum port spacing and orientation of hole locations shall be shown on the Contract Drawings. The ports shall be supplied with threaded port plugs. Port plugs shall be manufactured by the pipe manufacturer and shall be compatible with the pipe.
- F. Lubrication in the annulus outside the Jacking Pipe used during jacking to reduce friction and control the ground shall be a mixture of bentonite, water and additives and designed by the Contractor. The lubrication shall be non-toxic and shall not release environmental contaminants into the ground or groundwater either directly or from degradation over time.

2.02. EQUIPMENT

- A. The Contractor shall determine and provide the equipment necessary for the trenchless excavation and the installation of the jacking pipe and complete all work associated with this section. Determination of an adequate trenchless excavation size shall be the sole responsibility of the Contractor within the limitations specified herein and as shown on the Contract Drawings. The dimensions shown on the Contract Drawings represent the minimum dimensions and do not necessarily represent the size and/or section suitable for the construction methods, tolerances, or operation procedures as may be proposed and/or conducted by the Contractor. Changes to these dimensions shall not be allowed unless accepted by the Engineer.
- B. The Contractor shall use a TBM manufactured by a company that specializes in design and fabrication of this type of equipment. The TBM shall be sized so that it is capable of installing the proposed Jacking Pipe for each tunnel while maintaining adequate clearance to existing utilities and selected to be capable of dealing with soil conditions given in the GBR. The TBM shall include the following equipment:
 - 1. Stabilizer or extendable fins, and/or a bidirectional cutter head that allows the TBM to maintain a level of orientation and correct a condition in which the machine begins to roll.
 - 2. Be capable of being operated in open face or closed face modes, that will prevent loss of ground during tunneling and steerable and capable of controlling the advance of the heading to maintain line and grade within the tolerances specified.

3. Maximum 1 in. Overcut.
- C. The TBM position shall be monitored by a laser guidance system. The laser guidance system shall be designed to function at the maximum drive length without excessive laser beam diffusion. The laser shall be set in the launching shaft and supported independently of the launching shaft slab, walls, and thrust block.
- D. The jacking system shall be capable of continuously monitoring jacking pressure, rate of advancement, and distance jacked. The jacking system shall develop a uniform distribution of jacking forces around the end of the pipe. Use suitable cushioning to provide uniform bearing over the perimeter of the Jacking Pipe to distribute the jacking pressure evenly.
- E. Provide Intermediate Jacking Stations as necessary such that the estimated maximum jacking load needed to complete the drive does not exceed 80% of the maximum allowable jacking load for the pipe. Upon completion of the drive, close and seal Intermediate Jacking Stations.

PART 3 - EXECUTION

3.01. GENERAL:

- A. Perform all work in the presence of the Owner's Representative, unless the Representative has granted prior approval in writing to perform such work in his/her absence.
- B. The Contractor shall give the Engineer a minimum of ten days advance notice of the start of work.
- C. Design, install and operate trenchless excavation support utilities as necessary for support of construction and the safety of workers in accordance with project requirements and all Federal, State, and local laws, regulations, and codes.
- D. The equipment and methods the Contractor employs to perform the work shall be appropriate for the conditions set forth in the GBR. Perform tunneling operations in a manner that will minimize loss of ground and minimize movement of the ground surface, structures, and utilities above and adjacent to the tunnel.
- E. Do not begin tunneling until:

1. Required submittals have been made and the Engineer has reviewed and accepted submittals.
2. All required permits are in place and the governing agencies have been satisfactorily notified of the schedule and work.
3. Shaft/pit excavations, stabilization and shoring have been satisfactorily completed.
4. All monitoring and instrumentation points have been established and initial measurements have been obtained per Section 31 09 13 Geotechnical Instrumentation and Monitoring.
5. A pre-job safety conference has been conducted. Arrange this conference and inform the Engineer of the time and place of the conference at least seven days in advance of the tunnel construction.

F. Maintain clean working conditions at all times.

G. The Contractor shall have the sole responsibility for maintenance and protection of existing utilities, railroad tracks, structures, and facilities within the estimated settlement trough zone. Location of utilities shown on the Construction Drawings shall be considered approximate. The Contractor shall be responsible for locating each utility potentially impacted by the work to verify location prior to beginning the tunneling work.

3.02. SAFETY REQUIREMENTS:

- A. Methods of construction shall be such as to ensure the safety of the workers, project participants, the public, third parties, and adjacent property, whether public or private. The Contractor is solely and completely responsible for maintaining safe working conditions at the site at all times.
- B. Perform all work in accordance with the current applicable regulations of the Federal, State, and local agencies. In the event of conflict, comply with the more restrictive applicable requirements.

3.03. TUNNEL EXCAVATION:

- A. Tunneling shall be conducted to minimize movement of the ground in front of and surrounding the tunnel and to control the loss of ground, surface settlement, and

heave of the ground surface. Control the advance rate, volume of material excavated, and pressure applied to the tunnel face to avoid over excavation, loss of ground, and heave of the ground surface.

- B. Each pipe section shall be jacked forward as the excavation progresses in such a way as to provide complete and adequate support to the surrounding ground at all times. Installed pipes shall not be allowed to move backward while the jacks are retracted and the next pipe segment is placed.
- C. Carefully control and monitor volume of soil removed. Compare theoretical and actual volumes of soil removed. Adjust advance rate and excavation rate to avoid over excavation. Investigate potential voids created by over excavation.
- D. The Contractor is responsible to immediately repair any damages within the estimated settlement trough zone. Damages shall be repaired before the Contractor demobilizes from the site. Repairs shall be performed at no cost to the Owner.
- E. During shutdowns and other interruptions in tunnel excavation work provide complete positive support for the face by positioning the TBM cutterhead firmly against the face or provide alternative means of positive face support.
- F. Avoid damage to the Casing during jacking. In the event of damage to a pipe section or pipe joint, the Contractor shall notify the Engineer within the day of observation of the damage. If the damage is within the shaft, the Contractor shall remove the damaged section of pipe in a manner to allow welding of an undamaged pipe.
- G. All welding shall be done in accordance to AWS D1.1.
- H. The jacking loads shall be continuously monitored and recorded.
- I. The Contractor may design and implement a lubrication system outside the Jacking Pipe suitable for the soil conditions described in the GBR. If lubrication is used, the Contractor shall at all times monitor the volumes, pressures, and location of lubricant pumping to ensure that the annulus around the pipe is completely filled with lubricant.
- J. The contractor may employ 24-hour operations, if they deem necessary for successful tunnel installation.

3.04. EXCAVATED MATERIALS:

- A. The Contractor will dispose of excavated materials. Spoils disposal shall be the responsibility of the Contractor. Provide written documentation from the disposal site(s) indicating that they will accept the spoil and are in compliance with applicable regulations.

3.05. CONTROL OF LINE AND GRADE:

- A. Benchmarks and other primary survey control shall be established by the Contractor. The Contractor shall verify the accuracy of the benchmarks at beginning of construction and use correct benchmarks to furnish and maintain reference lines and grades. If deformation of ground surface occurs during construction which will affect the accuracy of either temporary or permanent benchmarks, it shall be the Contractor's responsibility to detect and report such movement, and to reestablish benchmarks.
- B. If laser alignment shifts or is moved off design alignment and grade, stop tunneling operations and reset laser. Monitor line and grade continuously during tunneling operations. Record deviation from design line and grade of the TBM at least every five feet of advance.
- C. Verification Survey. Survey and submit exact position of TBM and installed Jacking Pipe during tunneling to ensure alignment is within specified tolerances, independent of the guidance system. Independent surveys shall be performed every 100 ft of tunnel advance or more frequently. Verification survey shall include survey of each Jacking Pipe joint installed.
- D. The tunnel shall be installed to within ± 3 inches on grade, whichever is greater, and plus ± 6 inches on line.
- E. The Contractor is responsible for setting control points and controlling the line and grade of the tunnel as necessary to achieve the specified line, grade and tolerances for the Carrier Pipe. The invert of the Carrier Pipe shall be within ± 1 inches of the elevation shown on the Drawings. The Carrier Pipe shall have an alignment within ± 6 inch of the alignment shown on the Drawings. The Carrier Pipe alignment shall not change by more than 1 in. per 50 ft.

- F. If the Jacking Pipe is off line and/or grade by more than the specified tolerances, the Contractor shall make adjustments, repairs and changes as necessary to achieve the specified tolerances.
- G. If the tunnel is sufficiently far off line and/or grade to require redesign of structures, acquisition of easements, or backfilling and re-excavation, the Contractor shall be responsible for doing all additional work and costs.
- H. Steering corrections made to the tunnel alignment, if applicable, shall be carried out in such a manner that the joint angle of any two adjacent pipes or segments does not exceed allowable limits, and at a rate of not more than 1 in. per 25 ft.

3.06. TUNNEL ACCESS:

- A. Provide access for the Owner and Engineer at all times during active tunnel work. Access shall be for, but not be limited to, the following: to inspect and observe the work, to perform independent line and grade surveys, for geologic mapping, for monitoring of instrumentation, and for installation of additional instrumentation.

3.07. TUNNELING RECORDS:

- A. Contractor shall maintain Daily Shift Reports for all components and phases of tunnel excavation. The Shift Reports shall be signed by the Tunnel Superintendent and shall contain the following:
 - 1. Work crews and equipment onsite, and the work performed. The reports shall be broken down into work time and down/standby time for each crew and piece of equipment;
 - 2. Progress made for each construction stage;
 - 3. Survey results – line and grade;
 - 4. Problems or unusual conditions encountered and actions taken to address these situations;
 - 5. Start and finish time of advancement for each pipe section;
 - 6. Rate of advance including total distance tunneled at the end of each day;
 - 7. Jacking load at each jacking station, including the number of cylinders used.

8. Maximum jacking force exerted during the installation of each pipe section including pipe breakout peaks following periods of system shutdown.
 9. Volume and placement location of lubrication, if used;
 10. TBM cutterhead torque, rpm, and rotation direction;
 11. Lubricant injecting injection pressure.
 12. Volume of lubricant injected, location, and frequency of injection.
 13. Daily theoretical tunnel volume of soil removed vs daily actual volume of soil removed;
 14. General description of each discernible ground condition mined.
- B. Contractor shall maintain records of all surveys.
- C. Contractor shall maintain records of all instrumentation and monitoring of the tunnel excavation including but not limited to the following:
1. The station of the face of the excavation and advance distance.
 2. The deviation of the TBM from design line and grade; attitude including square, plumb, and roll.
 3. The date, starting time, and finish time.
 4. Any unusual conditions, breakdowns, and delays.
- D. As-built drawings for each tunnel shall be based on the surveyed locations of each final pipe joint invert location and elevation determined by a licensed surveyor registered in the State of Colorado. As-built drawings shall be submitted and accepted by the Engineer prior to recommending final payment.

3.08. CLEANUP AND RESTORATION

- A. Remove all equipment, unused materials, and debris from the site at the end of the job. Restoration shall follow construction as the work progresses and shall be completed as soon as possible. Restore and repair any damage resulting from surface settlement caused by the work. Any property or improvements damaged or destroyed, shall be restored to a condition equal to or better than existing prior to construction at

no additional cost to the Owner. Restoration shall be completed immediately if a third party or the Owner are inconvenienced by the damage, and in no case later than 30 days after the damage is discovered. This provision for restoration shall include all property which was affected by the construction operations.

- B. At the end of every construction day, construction equipment and materials shall be removed as far from operating railroad tracks as possible (minimum 25 ft from centerline).

END OF SECTION

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SECTION 31 71 40

TRENCHLESS INSTALLATION BY MICROTUNNEL BORING MACHINE

PART 1 - GENERAL

1.01. DESCRIPTION:

- A. This section includes the requirements for the installation of Jacking Pipe using Microtunnel Boring methods.
- B. The Scope of Work to be performed under this section includes:
 - 1. Designing, detailing, fabricating, and installing Jacking Pipe by Microtunnel Boring methods as shown on the Contract Drawings and to the line and grade tolerances specified herein.
 - 2. Labor, material, tools, equipment, and incidentals necessary to complete the work described above.
 - 3. Spoil hauling and disposal.
- C. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements. The Contractor shall select and utilize methods and equipment compatible with the dimensions of the tunnels shown and with anticipated geologic conditions described in the Geotechnical Baseline Report (GBR).
- D. The following Jacking Pipes are approved for the tunnels on this project:
 - 1. Steel

1.02. REFERENCES:

- A. Geotechnical Reports
 - 1. Report dated April 17, 2026, prepared by Brierley Associates entitled "Geotechnical Baseline Report, Thornton Water Project – Segment F.1"
 - 2. Report dated July 15, 2026, prepared by CMT entitled "Geotechnical Data Report, Thornton Water Project – Segment F.1"

B. Applicable Standards:

1. Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Subpart S (Underground Construction)
2. American National Standards Institute (ANSI) / American Association of State Highway and Transportation Officials (AASHTO) / American Welding Society (AWS) D1.1 - Structural Welding Code.
3. ASTM A1097 Standard Specification for Steel Casing Pipe, Electric-Fusion (Arc)-Welded.
4. American Water Works Association (AWWA) C200 Steel Water Pipe.
5. American Railway Engineering and Maintenance-of-Way Association (AREMA).

1.03. DEFINITIONS:

- A. Carrier Pipe: Pipe that carries the product material.
- B. Face: The location where excavation takes place; the head of the tunnel excavation; typically, vertical or near vertical.
- C. Intermediate Jacking Station: Series of hydraulic jacks spaced around Jacking Pipe circumference and temporarily installed between two Jacking Pipe segments inside a steel casing fabricated to the same outside diameter as the Jacking Pipe
- D. Launch Seal/Receiving Seal: Rubber seals attached to the shaft walls to prevent inflow of soil, groundwater, and lubricant between the Jacking Pipe and hole in the shaft support.
- E. Lubricant: Bentonite suspension used to fill and pressurize the annular space between the MTBM and ground and between the Jacking Pipe and ground.
- F. Jacking Frame: A structural component in the launching shaft, fitted with hydraulic cylinders, which is used to push the cutting head and Jacking Pipe string into the ground for pipe jacking methods. The Jacking Frame serves to distribute the thrust load to the pipe string and the reaction load to the Thrust Block.
- G. Jacking Pipe: The steel pipe jacked behind the boring machine to provide ground support during tunneling and to act as the Casing Pipe in two-pass installations.

- H. Microtunnel Boring Machine (MTBM): A closed-face, remotely operated, steerable, laser-guided, articulated shield advanced by pipe jacking that is capable of exerting a continuous and controllable pressure at the tunnel heading by slurry pressure to counter-balance earth and water pressures. Spoils are mixed with the slurry and removed by transport through slurry lines at a controlled rate to maintain the required face pressure.
- I. Overcut: The difference between the radius of the outside of the MTBM cutters, and the outside of the Jacking Pipe.
- J. Slurry: Water mixture, which may contain additives, that is used to transport the spoils and counter-balance soil and groundwater pressure at the face
- K. Thrust Block: An engineered structure located between the Jacking Frame and the launch shaft wall to transfer the jacking force through the shaft support into the ground.
- L. Two Pass Tunneling System: A method of trenchless excavation in which Jacking Pipe is installed prior to installation of the Carrier Pipe.
- M. Settlement Trough: Width of zone above tunnel that is affected by settlement from trenchless excavations.

1.04. QUALIFICATIONS:

- A. The Tunnel Contractor shall have a minimum of five years of experience on pipe jacking projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.
- B. The Tunnel Superintendent shall have a minimum of ten years of civil construction experience on pipe jacking projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.
- C. The Tunnel Operator shall have a minimum of five years of experience on pipe jacking projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.
- D. Project control points must be set by a Surveyor licensed by the State of Colorado and have at least five years' experience in surveying.

- E. Design of engineered structures as defined herein shall be signed and sealed by a Registered Professional Engineer in the State of Colorado with a minimum of five years of experience in structural design of tunnels and/or shafts as appropriate.
- F. Welders shall be qualified under the provisions of AWS D1.1.

1.05. SUBMITTALS:

- A. Submit in accordance with Section 01 33 00.
- B. At least 90 days prior to the start of work, all submittals, including drawings and calculations, shall be required for the sole purpose of providing Engineer sufficient details to confirm that the Contractor planned work and work in progress is in accordance with Contract Documents. Engineer's review shall not be construed to relieve Contractor in any way of responsibilities under the Contract. Do not begin work on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer.
- C. Preconstruction. Submit the following qualifications:
 - 1. The name and qualifications of the Tunnel Contractor.
 - 2. The name and qualifications of the Tunnel Superintendent.
 - 3. The name and qualifications of the Tunnel Operator.
 - 4. The name and qualifications of the Tunnel Surveyor.
 - 5. The name and certifications of the welders.
- D. Preconstruction: Submit a Tunnel Work Plan, including the following:
 - 1. A detailed description of the tunneling equipment and procedures to be employed. Provide manufacturer's literature describing tunneling system in detail including machine type, any design modifications, spoils removal system, guidance system, and provisions for injecting pipe lubricants.
 - 2. Letter from the tunnel boring machine manufacturer certifying that the proposed machine has been inspected by qualified mechanics and found free of defects or mechanical deficiencies prior to construction.

3. Description of tunnel excavation equipment to be used including: original manufacturer; model or type; machine capabilities and procedures for exerting a stabilizing pressure at the tunnel heading and minimizing loss of ground. Indicate range of pressures anticipated to stabilize the heading, and methods and equipment to be used to monitor and control pressures.
4. Detailed drawings and dimensions of equipment configuration; amount of overcut; propulsion system, and layout of excavation and ancillary equipment for the tunnel.
5. Jacking equipment including: manufacturer; drawings and dimensions of equipment configuration; jack arrangement; capacity; and thrust ring design. Submit Jacking Frame and Thrust Block shop drawings and calculations stamped by a Professional Engineer registered in the State of Colorado. Demonstrate that the anticipated jacking forces will be safely transmitted to the launching shaft shoring and are coordinated with the launch shaft shoring design.
6. Capacity, number, and arrangement of main jacks, provide details of thrust ring, jacking controls and pressure gages. Provide an estimate of the maximum jacking force expected. Include locations, jack arrangement, capacity, jack interface with pipe, and method of closure for intermediate jacking stations (if used).
7. Details of the Jacking Pipe to be used indicating pipe wall thickness, joint details. Indicate the required fabrication tolerances to prevent damage to the pipe during installation and provide a certification from the pipe manufacturer indicating that the Jacking Pipe is designed adequately for the project requirements and will perform acceptably.
8. Design calculations demonstrating the proposed Jacking Pipe is capable of supporting the maximum stresses to be imposed on the pipe during handling and jacking. The calculations should take into account the maximum: ground and hydrostatic loads, jacking forces, external loads such as live loads due to traffic/railroad, and any other loads. The calculations shall include design for allowable deflection and buckling and estimated jacking loads. Calculations shall be prepared, sealed, and signed by a Professional Engineer registered in the State of Colorado.
9. Details of pipe lubrication injection system and pipe lubricants used during tunneling including Manufacturer's literature.

10. A description of the guidance and steering systems. Provide manufacturer's literature, drawings showing set up and support provisions, and other details for alignment control. Submit a description of surveying methods during construction. Confirm that systems can achieve required line and grade within specified tolerances.
11. Procedures for measuring excavation quantities versus forward progress during the tunneling operation.
12. Settlement Calculations: The Contractor shall provide calculations that estimate the dimensions of the settlement trough. All calculations shall be signed and sealed by a licensed State of Colorado Professional Engineer.
13. Spoil and/or slurry handling, separation, transport, and disposal equipment and procedures including details of slurry or soil conditioning additives, slurry separation plant, and the location of slurry and spoil disposal sites. Provide manufacturers description for slurry additives and Material Safety Data Sheets (MSDSs). Provide a plan describing procedure for containing and cleaning up any slurry spills or unintentional releases.
14. If manned entry methods are used, Contractor's plan for personnel conducting tunneling operations including provisions for ventilation, temperature control, lighting, electrical safeguards, safety of the public, monitoring, and warning systems.
15. Schedule of advance indicating the anticipated start and end dates, startup and completion periods, and rate of advance for different phases of tunneling. A critical path schedule of tunneling-related activities and activities for project components interfacing with the tunnel indicating the anticipated start and end dates, startup and completion periods. Include as a minimum the following activities: mobilization, jacking equipment setup, tunneling, contact grouting, site restoration, demobilization, and cleanup. Include number of working days per week, shifts per day, and hours per shift.
16. A general Contingency Plan, procedures, and details for completing the tunnel in the event any of the following scenarios.
 - a. Scenario 1 – Strong hydrocarbon smell is detected in the spoils.

- b. Scenario 2 – The tunnel advance encounters a hard obstruction. Provide contingencies for each case when the obstruction is equal to or less than $\frac{1}{3}$ the tunnel diameter and greater than $\frac{1}{3}$ the tunnel diameter, taking into consideration surface access issues.
 - c. Scenario 3 – The tunnel encounters a fibrous obstruction such as timber, taking into consideration surface access issues.
 - d. Scenario 4 – A blowout or spill of lubrication or grout occurs at the ground surface.
 - e. Scenario 5 – Settlement is detected near a road or railroad crossing during tunneling operations.
 - f. Scenario 6 – High jacking loads cause damage to the Jacking Pipe or stop advancement of the tunnel.
 - g. Scenario 7 – A major mechanical breakdown or equipment failure.
 - h. Scenario 8 – The target laser is distorted by heat and/or humidity in the tunnel or the target laser is knocked out of alignment.
 - i. Scenario 9 – Soil conditions cause the tunnel to deviate from line and grade or result in excessive settlement.
17. Contractor's safety plan for personnel conducting tunneling operations including provisions for ventilation, temperature control, lighting, electrical safeguards, safety of the public, monitoring, and warning systems. Submit a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.
- E. Construction. Submit the following during construction within the specified time restrictions:
- 1. Written Daily Logs as specified herein. The Daily Logs shall have field logs recorded for each shift and shall be submitted to the Engineer within one working day of excavation at each location
- F. Post-Construction:
- 1. Submit Jacking Pipe survey results within 24 hours of measurement.

2. As-built drawings for each tunnel shall be submitted to the Engineer within two weeks of completion.

PART 2 - PRODUCTS

2.01. JACKING PIPE:

- A. All loads shall be shown on the submitted calculations and described. Include assumed maximum drive length. The calculations shall include design for allowable deflection and buckling. All calculations shall be signed and sealed by a licensed State of Colorado Professional Engineer.
- B. Jacking Pipe shall be specifically designed for tunneling as appropriate. Where appropriate, the pipe shall be designed to carry Cooper E-80 Railroad or AASHTO HL-93 live loading. The Jacking Pipe shall be in accordance with the pipe manufacturer's specifications and guidelines for jacking as appropriate. The contractor shall adhere to pipe manufacturer's installation guidelines for: 1) handling, 2) launch shaft or pit preparations, 3) end preparations, mating procedures, and installation, and 4) special applications. Jacking pipes shall be capable of withstanding the jacking forces imposed during installation, and the final in-place loading conditions. The ends of the Jacking Pipe shall be protected against damage during installation.
- C. Steel Jacking Pipe shall be smooth wall welded steel cylinder fabricated in accordance with ASTM A1097, having a minimum yield strength of 36,000 pounds per square inch. The Jacking Pipe shall be fabricated in accordance with these standards unless the Contractor determines that tighter tolerances are required to avoid damage to the pipe during installation to successfully complete the tunnel drive lengths.
- D. The smallest inside diameter of the Jacking Pipe shall be a minimum of 12 in. larger than the largest outside diameter of the Carrier Pipe.
- E. Jacking Pipe joints shall be butt-welded, or lap welded around the entire joint perimeter to produce a watertight seal. Welds shall be of a size to develop the full strength of the pipe materials. Proprietary non-welded steel joints such as Tri-Loc or Permalok shall be installed in accordance with manufacturer's specifications.
- F. The Jacking Pipe shall be provided with ports for injection of lubricant and grout. Maximum port spacing, and orientation of hole locations shall be shown on the

Contract Drawings. The ports shall be supplied with threaded port plugs. Port plugs shall be manufactured by the pipe manufacturer and shall be compatible with the pipe.

- G. Lubrication in the annulus outside the jacking pipe used during jacking to reduce friction and control the ground shall be a mixture of bentonite, water and additives and designed by the Contractor. The lubrication shall be non-toxic and shall not release environmental contaminants into the ground or groundwater either directly or from degradation over time.

2.02. EQUIPMENT:

- A. The Contractor shall determine and provide the equipment necessary for the trenchless excavation and the installation of the Jacking Pipe and complete all work associated with this section.
- B. The Contractor shall use an MTBM manufactured by a company that specializes in design and fabrication of this type of equipment. The MTBM shall be sized so that it is capable of installing the specified pipe for each tunnel while maintaining adequate clearance to existing utilities and selected to be capable of dealing with soil conditions given in the GBR. The MTBM shall include the following equipment:
 - 1. A display showing position of the machine in relation to design line-and-grade provided at operation console to allow operator to monitor face pressure, roll, inclination, laser position, steering attitude, rate of advance, installed length, thrust force and cutter-head torque. The system shall be able to print this information.
 - 2. A closed excavation chamber capable of being adjusted as required to maintain face support at all times and balance earth and groundwater pressures to prevent loss of ground, groundwater inflow, and settlement or and heave of the ground surface. The excavation chamber shall have a pressure gauge allowing the operator to monitor pressure in chamber.
 - 3. The MTBM shall have stabilizer or extendable fins, and/or a bidirectional cutter head that allows the MTBM to maintain a level of orientation and correct a condition in which the machine begins to roll.
 - 4. A spoils transportation system capable of controlling slurry pressure and avoiding excessive pumping pressures to prevent heave or discharge of slurry at ground

surface and synchronizing rate of excavation with rate of machine advance to avoid over-excavation and loss of ground.

5. High-pressure jets capable of clearing debris from the excavation chamber.
 6. Tail seals to prevent material from flowing into tunnel at the contact between the tail skin and the Jacking Pipe.
 7. Provide temporary portable lighting and ventilation in tunnels and shafts as necessary for the Engineer to evaluate the conformance of the Jacking Pipe with the Contract Documents.
- C. The Overcut shall not exceed 1 in.
- D. The MTBM position shall be monitored by a laser guidance system. The laser guidance system shall be designed to function at the maximum drive length without excessive laser beam diffusion. The laser shall be set in the launching shaft and supported independently of the launching shaft slab, walls, and thrust block.
- E. For slurry spoil removal, provide a slurry separation plant appropriate for the anticipated excavated soils shown in the GBR, compatible with anticipated excavation rate, and effective in removing spoil from slurry. Use settlement tanks, shakers, vibrating screens, de-sanders, hydrocyclones, centrifuges, or combinations thereof, as required for effective spoil separation. Pump slurry into tanker trucks and dispose at an accepted location. Spoils shall be transported off site by the Contractor.
- F. The jacking system shall be capable of continuously monitoring jacking pressure, rate of advancement, and distance jacked. The jacking system shall develop a uniform distribution of jacking forces around the end of the pipe.

PART 3 - EXECUTION

3.01. GENERAL:

- A. Perform all work in the presence of the Owner's Representative, unless the Representative has granted prior approval in writing to perform such work in his/her absence.
- B. The Contractor shall give the Engineer a minimum of ten days advance notice of the start of work.

- C. Design, install and operate trenchless excavation support utilities as necessary for support of construction and the safety of workers in accordance with project requirements and all Federal, State, and local laws, regulations, and codes.
- D. The equipment and methods the Contractor employs to perform the work shall be appropriate for the conditions set forth in the GBR. Perform tunneling operations in a manner that will minimize loss of ground and minimize movement of the ground surface, structures, and utilities above and adjacent to the tunnel. Repair damage resulting from surface deformation caused by tunneling at no additional cost to the Owner.
- E. Do not begin tunneling until:
 - 1. Required submittals have been made and the Engineer has reviewed and accepted submittals.
 - 2. All required permits are in place and the governing agencies have been satisfactorily notified of the schedule and work.
 - 3. Shaft/pit excavations, stabilization and shoring have been satisfactorily completed in accordance with Section 31 75 00, Shaft Excavation and Support.
 - 4. All monitoring and instrumentation points have been established and initial measurements have been obtained per Section 31 09 13 Geotechnical Instrumentation and Monitoring.
 - 5. A pre-job safety conference has been conducted. Arrange this conference and inform the Engineer of the time and place of the conference at least seven days in advance of the tunnel construction.
- F. Support the MTBM on a cradle during initial setup at the correct horizontal and vertical line, grade and orientation.
- G. Maintain clean working conditions at all times.
- H. The Contractor shall have the sole responsibility for maintenance and protection of existing utilities, railroad tracks, structures, and facilities within the estimated settlement trough zone. Location of utilities shown on the Construction Drawings shall be considered approximate. The Contractor shall be responsible for locating each utility potentially impacted by the work to verify location prior to beginning the tunneling work.

3.02. SAFETY REQUIREMENTS:

- A. Methods of construction shall be such as to ensure the safety of the workers, project participants, the public, third parties, and adjacent property, whether public or private. The Contractor is solely and completely responsible for maintaining safe working conditions at the site at all times.
- B. Perform all work in accordance with the current applicable regulations of the Federal, State, and local agencies. In the event of conflict, comply with the more restrictive applicable requirements.

3.03. TUNNEL EXCAVATION:

- A. Tunneling shall be conducted to minimize movement of the ground in front of and surrounding the tunnel and to control the loss of ground, surface settlement, and heave of the ground surface. Control the advance rate, volume of material excavated, and pressure applied to the tunnel face to avoid over excavation, loss of ground, and heave of the ground surface.
- B. Each pipe section shall be jacked forward as the excavation progresses in such a way as to provide complete and adequate support to the surrounding ground at all times. Installed pipes shall not be allowed to move backward while the jacks are retracted, and the next pipe segment is placed.
- C. Carefully control and monitor volume of soil removed. Compare theoretical and actual volumes of soil removed. Adjust advance rate and excavation rate to avoid over excavation. Investigate potential voids created by over excavation.
- D. The Contractor is responsible to immediately repair any damages within the estimated settlement trough zone. Damages shall be repaired before the Contractor demobilizes from the site. Repairs shall be performed at no cost to the Owner.
- E. During shutdowns and other interruptions in tunnel excavation work provide complete positive support for the face by positioning the cutterhead firmly against the face or provide alternative means of positive face support.
- F. Avoid damage to pipe sections and joints during jacking. In the event of damage to a pipe section or pipe joint, the Contractor shall notify the Engineer within the day of observation of the damage. If the damage is within the shaft, the Contractor shall

remove the damaged section of pipe in a manner to allow welding of an undamaged pipe.

- G. All welding shall be done in accordance with AWS D1.1.
- H. The jacking loads shall be continuously monitored and recorded.
- I. The Contractor shall design and implement a lubrication system outside the pipe suitable for the soil conditions described in the GBR. If lubrication is used, the Contractor shall at all times monitor the volumes, pressures, and location of lubricant pumping to ensure that the annulus around the pipe is completely filled with lubricant.
- J. The contractor may employ 24-hour operations, if they deem necessary for successful tunnel installation.

3.04. EXCAVATED MATERIALS:

- A. The Contractor will dispose of excavated materials. Spoils and slurry disposal shall be the responsibility of the Contractor. Provide written documentation from the disposal site(s) indicating that they will accept the spoil or slurry and are in compliance with applicable regulations.

3.05. CONTROL OF LINE AND GRADE:

- A. Benchmarks and other primary survey control shall be established by the Contractor. The Contractor shall verify the accuracy of the benchmarks at beginning of construction and use correct benchmarks to furnish and maintain reference lines and grades for microtunneling. If deformation of ground surface occurs during construction which will affect the accuracy of either temporary or permanent benchmarks, it shall be the Contractor's responsibility to detect and report such movement, and to reestablish benchmarks.
- B. If laser alignment shifts or is moved off design alignment and grade, stop tunneling operations and reset laser. Monitor line and grade continuously during tunneling operations. Record deviation from design line and grade of the MTBM at least every five feet of advance.
- C. Verification Survey. Survey and submit exact position of MTBM and installed Jacking Pipe during tunneling to ensure alignment is within specified tolerances, independent of the guidance system. Independent surveys shall be performed every 100 ft of tunnel

advance or more frequently. Verification survey shall include survey of each Jacking Pipe joint installed.

- D. The Jacking Pipe shall be installed to within ± 3 inches on grade, whichever is greater, and plus ± 6 inches on line.
- E. The Contractor is responsible for setting control points and controlling the line and grade of the tunnel as necessary to achieve the specified line, grade and tolerances for the Carrier Pipe. The invert of the Carrier Pipe shall be within ± 1 inches of the elevation shown on the Drawings. The Carrier Pipe shall have an alignment within ± 6 inch of the alignment shown on the Drawings. The Carrier Pipe alignment shall not change by more than 1 in. per 50 ft.
- F. If the Jacking Pipe is off line and/or grade by more than the specified tolerances, the Contractor shall make adjustments, repairs and changes as necessary to achieve the specified tolerances.
- G. If the tunnel is sufficiently far off line and/or grade to require redesign of structures, acquisition of easements, or backfilling and re-excavation, the Contractor shall be responsible for doing all additional work and costs.
- H. Steering corrections made to the tunnel alignment, if applicable, shall be carried out in such a manner that the joint angle of any two adjacent pipes or segments does not exceed allowable limits, and at a rate of not more than 1 in. per 25 ft.

3.06. TUNNEL ACCESS:

- A. Provide access for the Owner and Engineer at all times during active tunnel work. Access shall be for, but not be limited to, the following: to inspect and observe the work, to perform independent line and grade surveys, for geologic mapping, for monitoring of instrumentation, and for installation of additional instrumentation.

3.07. TUNNELING RECORDS:

- A. Contractor shall maintain Daily Shift Reports for all components and phases of tunnel excavation. The Shift Reports shall be signed by the Tunnel Superintendent and shall contain the following:
 - 1. Work crews and equipment onsite, and the work performed. The reports shall be broken down into work time and down/standby time for each crew and piece of equipment;

2. Progress made for each construction stage;
 3. Survey results – line and grade;
 4. Problems or unusual conditions encountered, and actions taken to address these situations;
 5. Start and finish time of advancement for each pipe section;
 6. Rate of advance including total distance jacked at the end of each day;
 7. Jacking load at each jacking station, including the number of cylinders used.
 8. Maximum jacking force exerted during the installation of each pipe section including pipe breakout peaks following periods of system shutdown.
 9. Volume and placement location of lubrication, if used;
 10. MTBM cutterhead torque, rpm, and rotation direction;
 11. Volumetric flow rates in supply side and return side of slurry loop.
 12. Slurry bypass valve position.
 13. Slurry pressure in slurry chamber in cutterhead.
 14. Lubricant injection pressure.
 15. Volume of lubricant injected, location, and frequency of injection.
 16. Daily theoretical tunnel volume of soil removed vs daily actual volume of soil removed;
 17. General description of each discernible ground condition mined;
- B. Contractor shall maintain records of all surveys.
- C. Contractor shall maintain records of all instrumentation and monitoring of the tunnel excavation including but not limited to the following:
1. The station of the face of the excavation and advance distance.

2. The deviation of the MTBM from design line and grade; attitude including square, plumb, and roll.
 3. The date, starting time, and finish time.
 4. Any unusual conditions, breakdowns, and delays.
- D. Construction Record Drawings. The Contractor shall keep and maintain at the construction site a complete set of final design drawings for recording as-built conditions. The Contractor shall mark or note thereon all field information, properly dated, recording as-built conditions. This set of field drawings shall be kept up-to-date during the course of the project, and at a minimum once per day.
- E. As-built drawings for each tunnel shall be based on the surveyed locations of each final pipe joint invert location and elevation determined by a licensed surveyor registered in the State of Colorado. As-built drawings shall be submitted and accepted by the Engineer prior to recommending final payment.
- 3.08. CLEANUP AND RESTORATION:
- A. Remove all equipment, unused materials, and debris from the site at the end of the job. Restoration shall follow construction as the work progresses and shall be completed as soon as possible. Restore and repair any damage resulting from surface settlement caused by the work. Any property or improvements damaged or destroyed, shall be restored to a condition equal to or better than existing prior to construction at no additional cost to the Owner. Restoration shall be completed immediately if a third party or the Owner are inconvenienced by the damage, and in no case later than 30 days after the damage is discovered. This provision for restoration shall include all property which was affected by the construction operations.
- B. At the end of every construction day, construction equipment and materials shall be removed as far from operating railroad tracks as possible (minimum 25 ft from centerline).

END OF SECTION

SECTION 31 73 00

CONTACT GROUTING

PART 1 - GENERAL

1.01. DESCRIPTION:

- A. This section includes the requirements for filling the annular space between the Casing Pipe and the existing ground with Contact Grout.
- B. Labor, material, tools, equipment, and incidentals necessary to complete the work described above.
- C. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements. The Contractor shall select and utilize methods and equipment compatible with the dimensions of the tunnels shown and with anticipated geologic conditions described in the Geotechnical Baseline Report (GBR).

1.02. REFERENCES:

- A. Geotechnical Reports
 - 1. Report dated April 17, 2026, prepared by Brierley Associates entitled "Geotechnical Baseline Report, Thornton Water Project – Segment F.1"
 - 2. Report dated July 15, 2026, prepared by CMT entitled "Geotechnical Data Report, Thornton Water Project – Segment F.1"
- B. ASTM International (ASTM):
 - 1. C 109: Standard test method for Compressive Strength of Hydraulic Cement Mortars (using 2-in, or [50-mm] cube specimens)
 - 2. C 144: Standard specification for Aggregate for Masonry Mortar
 - 3. C 150: Standard specification for Portland Cement
 - 4. C 494: Standard specification for Chemical Admixtures for Concrete,

5. C 618: Standard specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
6. C 827 Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens of Cementitious Mixtures
7. C 939: Standard test method for Flow of Grout for Preplaced Aggregate Concrete (Flow Cone Method)
8. C 940: Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory
9. C 1064: Standard Test Method for Temperature of Freshly Mixed Hydraulic-Cement Concrete
10. D 4380: Standard Test Method for Density of Bentonitic Slurries

C. Applicable Regulations:

1. Perform work in accordance with all applicable federal, state, and local regulations, codes, and standards. In the event of conflict, comply with more stringent requirement.

1.03. DEFINITIONS:

- A. Contact Grouting: The controlled injection of grout slurry at the interface between the Jacking Pipe and the ground, to fill voids and achieve contact.
- B. Casing Pipe: The steel pipe used to provide ground support during tunneling.

1.04. QUALIFICATIONS:

- A. The Contractor or Subcontractor who performs Contact Grouting shall be experienced in Contact Grouting in tunnels and underground projects with soil conditions, using methods, materials, and equipment comparable to this project.
- B. The Contact Grouting Supervisor shall have at least five years of Contact Grouting experience on pipe jacking projects with similar pipe diameters, materials, and ground conditions using the proposed tunneling method.

1.05. SUBMITTALS:

- A. Submit in accordance with Section 01 33 00.
- B. At least 90 days prior to the starts of work, all submittals, including drawings and calculations, shall be required for the sole purpose of providing Engineer sufficient details to confirm that the Contractor planned work and work in progress is in accordance with Contract Documents. Engineer's review shall not be construed to relieve Contractor in any way of responsibilities under the Contract. Do not begin work on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer.
- C. Submittals involving design work requiring a Professional Engineer shall be signed and sealed by a Professional Engineer registered in the State of Colorado.
- D. Preconstruction. Submit the following qualifications:
 - 1. The name and qualifications of the Contact Grout Contractor.
 - 2. The name and qualifications of the Contact Grouting Supervisor.
- E. Preconstruction: Submit a Contact Grouting Work Plan, including the following:
 - 1. A schedule for Contact Grouting work identifying all major construction activities as independent items. Include working hours for each activity, and a written description of construction methods and equipment, to be employed in completing work activities shown on the schedule and update weekly.
 - 2. Descriptions and shop drawings describing and illustrating methods and equipment proposed for all stages of the Contact Grouting operation including injection methods for Contact Grout including pumping equipment, mixer, agitator, hoses, boosters, pumping distances, return flow lines, flow rates, and pressure gauges. Include methods and description of instrumentation to monitor and control placement of the grout, proposed grout pressures, and procedures to be used to verify complete placement and check for voids.
 - 3. Mix design for the Contact Grout including proportions of all constituents, properties of the wet mix, test results of the wet mix, and test results of the cured backfill. The submittal shall fulfill all the requirements for materials specified herein. Trial contract grout mix tests shall be performed on samples made using the same materials, including water and cement that will be used in

production, at 24 hours, 7 days, and 28 days. Results of the 24-hour strength tests shall be used as a quality control check on the likely Contact Grout strength at 7 and 28 days.

4. Drawings and description of Contact Grout ports, plugs, and valves for the ports, and materials used to plug and permanently seal the Contact Grout ports following Contact Grouting.
5. Calculations and/or manufacturer information verifying that the proposed Casing Pipe will adequately withstand proposed grouting pressures.

F. Construction. Submit the following during construction within the specified time restrictions:

1. Test results of the Contact Grout. Submittals shall include results of all tests specified herein for the Contact Grout including but not limited to field tests and laboratory tests within 24 hours of the results being available.
2. Daily Logs as specified herein. Submit logs daily for the previous day's work.

1.06. QUALITY CONTROL:

A. Contractor shall provide testing of Contact Grout verification of material properties. Samples of Contact Grout shall be obtained at the point of discharge or alternatively at a simulated point of discharge through the same or greater pumping distance.

1. Index Testing of Contact Grout performed on: the first batch of Contact Grout mixed each day; for each additional 150 cf of Contact Grout placed, or fraction thereof; and after a change in mix design. Index tests shall include:
 - a. a set of compression tests
 - b. unit weight
 - c. temperature
 - d. viscosity
2. Compression Testing of Contact Grout: One set shall include five 2-in. diameter by 4-in. high cylinder samples. Testing shall be in accordance with ASTM C 39. One sample shall be tested at an age of 24 hours, one sample shall be tested at

an age of seven days, and two samples shall be tested at an age of 28 days. One sample shall be held in storage.

PART 2 - PRODUCTS

2.01. MATERIALS:

- A. Portland cement shall be in accordance with ASTM C150.
- B. Contact Grout. Contact Grout shall be a mixture of Portland cement and water with a maximum water/cement ratio of 1:1 by volume, where the volume of cement is based on the bulk unit weight where one 94-lb sack equals one cubic foot. 24-hour compressive strength shall be at least 200 psi, 7-day strength at least 500 psi, and 28-day strength at least 500 psi.
- C. Contact Grout trial mix shall exhibit no more than five percent bleed as measured according to ASTM C940.
- D. Contact Grout shall have a wet specific gravity between 1.69 and 1.75 when measured with a Baroid Mud Balance in accordance with ASTM D4380.
- E. Contact Grout temperature at time of injection shall be between 50° F and 90° F when measured according to ASTM C1064.
- F. Contact Grout viscosity shall be measured according to ASTM C939. Flow time at time of injection shall be between 18 and 35 seconds.
- G. Water shall be potable.
- H. Contact Grout Port Plugs: Contact Grout port plugs shall be compatible with the Pipe. The plugs shall be watertight and leave the tunnel interior with a smooth surface. The plugs shall be rated to a pressure of at least 100 psi.

2.02. EQUIPMENT:

- A. Contact Grouting Equipment
 - 1. The Contractor shall determine the equipment needed to successfully conduct the Contact Grouting and control the work.
 - 2. As a minimum, the Contractor's Contact Grouting equipment shall consist of:

- a. If mixed on-site, the water shall be metered, and a high-speed shear mixer used;
 - b. Paddle type agitator;
 - c. Progressing helical cavity (Moyno) grout pump or equivalent pump that provides controlled pressure and flow rate;
 - d. Contact Grouting header assembly. The piping shall include a spigot with valve at the injection point for taking Contact Grout samples.
- 3. The Contact Grouting equipment shall include controls on the proportioning and mixing of the Contact Grout sufficient to assure the designed mix is achieved.
 - 4. A flow meter shall be provided at the injection point with a range suitable for the expected Contact Grout flows and measuring the rate of flow to an accuracy of 0.2 gpm or better. A total flow indicator shall be provided measuring the Contact Grout injected at each port to an accuracy of 1 gallon or better.
 - 5. A pressure gauge shall be provided at the injection point with a range selected so that the anticipated grouting pressure is in the middle third and reading to an accuracy of 0.2 psi or better.
- B. Communications Equipment. The Contractor shall provide equipment to communicate between workers in the tunnel at the Contact Grout injection points with workers outside the tunnel.

PART 3 - EXECUTION

3.01. GENERAL:

- A. The Contractor shall give the Engineer a minimum of 10 days advance notice of the start of work.
- B. Perform all work in the presence of the Owner's Representative, unless the Representative has granted prior approval in writing to perform such work in his absence.
- C. Contact Grouting shall be conducted under the direct supervision of the Contact Grouting Supervisor.

- D. Contact Grouting of the Casing Pipe shall be started within three days and completed within one week of the completion of tunneling for each tunnel drive.
- E. Contractor shall perform Contact Grouting operations in a manner that will limit ground movements, displacement of the Casing Pipe, and the movement of structures and utilities, if any, above and adjacent to the tunnel. Monitoring for ground movement shall be as specified in Section 31 09 13.

3.02. SAFETY REQUIREMENTS:

- A. Methods of construction shall be such as to ensure the safety of the workers, project participants, the public, third parties, and adjacent property, whether public or private. The Contractor is solely and completely responsible for maintaining safe working conditions at the site at all times.

3.03. MAINTENANCE:

- A. Maintain clean working conditions at all times inside the tunnel and shafts. All excess material, slush, Contact Grout spills, ponded water, and any other unused material or byproduct of the work shall be removed from the tunnel and the excavation daily.

3.04. CONTACT GROUTING:

- A. Contact Grouting shall be staged from inside the tunnel and done through preinstalled ports in the Casing Pipe.
- B. Contact Grouting shall be completed before installation of carrier pipe.
- C. Pressure gauges of appropriate diameters and ranges for monitoring the Contact Grouting injection pressures shall be located as close as possible to the point of injection in the line transporting the Contact Grout.
- D. Shutoff valves shall be supplied for Contact Grout ports in the vicinity of active Contact Grouting. The Contractor shall supply a sufficient number of shutoff valves to observe Contact Grout communication at least 50 ft in front of the port being Contact Grouted. Additional shutoff valves shall be provided by the Contractor if valves on previously Contact Grouted holes are not replaced with plugs as Contact Grouting progresses.
- E. Contact Grouting at each location shall begin at the lower ports with higher ports used for verification, followed by Contact Grouting through upper ports. Contact Grout using methods and procedures that track the movement of Contact Grout and verify

presence of Contact Grout throughout the tunnel by injecting Contact Grout at one port and using nearby ports to detect the presence of Contact Grout. Sequentially close off and move injection points to ensure full Contact Grout coverage.

- F. The volume of Contact Grout injected shall be measured, recorded, and compared with the anticipated volume per foot of Contact Grout expected. The advance of the grout shall be monitored by recording communication at nearby Contact Grout ports.
 - G. The Contact Grouting pressure shall be determined by the Contact Grouting Supervisor and based on recommendations from the Pipe manufacturer; the pressure shall be sufficient for the Contact Grout to fill voids surrounding the Jacking Pipe. Maximum allowable Contact Grouting pressure shall be maintained from the start of Contact Grout injection of each hole to refusal of the hole. The maximum Contact Grout pressure at all locations shall be less than the pressure that would cause ground heave and/or cause hydraulic fracturing or damage to the Pipe.
 - H. Maximum Contact Grout injection port spacing, and hole locations shall as shown on the Contract Drawings.
 - I. Refusal. Contact Grouting of any injection port shall be considered complete when the Contact Grout take is 1.5 gallons of Contact Grout or less during a minimum of 5 minutes of pumping at maximum injection pressure.
 - J. After completion of Contact Grouting, replace plug, and fill or patch in accordance with manufacturers specifications and recommendations.
 - K. Maintain a supply of water in the tunnel at the location of the Contact Grouting operations to facilitate flushing of injection lines or outlets.
 - L. All work areas shall have sufficient lighting to facilitate proper performance and inspection of work.
- 3.05. DAILY LOGS:
- A. Maintain Daily Logs of the work. As a minimum the Daily Logs shall contain the following:
 - 1. Work hours, equipment and crews in use with persons and craft designations.
 - 2. Stations of Contact Grouting.

3. Volume and pressures injected at each location.
4. Contact Grout sequence with take at each port and observations of return from nearby holes.
5. Record of holes Contact Grouted with locations, quantities, pressures, injection times, and verifications used.
6. Problems or unusual conditions encountered, and actions taken to address these situations.

END OF SECTION

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SECTION 31 75 00

CONSTRUCTION SHAFTS

PART 1 - GENERAL

1.01. DESCRIPTION:

- A. This section includes the requirements for designing, furnishing and installing, maintaining, and removing shaft shoring.
- B. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements. The Contractor shall select and utilize methods and equipment compatible with the dimensions of the tunnels shown and with anticipated geologic conditions described in the Geotechnical Baseline Report (GBR).
- C. The scope of work to be performed under this section includes:
 - 1. Designing and installing temporary shaft shoring.
 - 2. Labor, material, tools, equipment, and incidentals necessary to complete the work described above.
 - 3. Removing or abandoning the approved shoring structure.
- D. The Contractor shall give the Engineer a minimum of seven days' notice of the start of work.
- E. Perform all work in the presence of the Owner's representative, unless the representative has granted prior approval in writing to perform such work in his/her absence.
- F. Underground utilities are present. Prevent the work from entering, clogging, heaving or affecting adjacent underground utilities.
- G. Ground support for shafts and excavations shall stay within established easements unless the Contractor obtains additional easements, permits and approvals from affected property owners. The Contractor is responsible for abiding by the requirements of existing permits obtained by others.

1.02. REFERENCES:

A. Geotechnical Reports

1. Report dated April 17, 2026, prepared by Brierley Associates entitled "Geotechnical Baseline Report, Thornton Water Project – Segment F.1"
2. Report dated July 15, 2026, prepared by CMT entitled "Geotechnical Data Report, Thornton Water Project – Segment F.1"

B. Applicable Standards:

1. Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Subpart S (Underground Construction)
2. American National Standards Institute (ANSI) / American Association of State Highway and Transportation Officials (AASHTO) / American Welding Society (AWS) D1.1 - Structural Welding Code.
3. Burlington Northern Santa Fe (BNSF) and United Pacific Railroad (UPRR) Guidelines for Temporary Shoring (2021).
4. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR Part 1926 - Safety and Health Regulations for Construction.
5. American Railway Engineering and Maintenance-of-Way Association (AREMA)

1.03. DEFINITIONS:

- A. Launching Shaft: Excavation with ground support for launching and support of tunneling equipment.
- B. Receiving Shaft: Excavation with ground support for retrieval of the tunneling equipment.
- C. Dewatering: Removal of groundwater from the ground outside or inside shafts.
- D. Shoring: A temporary structural system designed to support soil and surcharge loads for purposes of excavation. Sloping of the soil is not shoring. Properly designed trench boxes or slide rail systems are acceptable for shoring.

1.04. QUALIFICATIONS:

- A. The Contractor performing the work shall have performed shaft construction using similar methods to those proposed for a minimum of five years on at least three separate projects.
- B. Project control points shall be set by a surveyor licensed by the State of Colorado and have at least five years of related experience in surveying.
- C. Only use welders qualified by tests prescribed in AWS D1.1, as applicable.

1.05. SUBMITTALS:

- A. Submit in accordance with Section 01 33 00.
- B. At least 90 days prior to the starts of work, all submittals, including drawings and calculations, shall be required for the sole purpose of providing the Engineer enough details to confirm that the Contractor's planned work and work in progress is in accordance with Contract Documents. The Engineer's review shall not be construed to relieve the Contractor in any way of responsibilities under the Contract Documents. Do not begin work on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer. All other engineered components shall be signed and sealed by a Professional Engineer licensed in the State of Colorado.
- C. At least four weeks prior to the start of work, submit the following qualifications:
 - 1. The name and qualifications of the Contractor that will perform the work with descriptions of reference projects including the Owner's name and contact information.
 - 2. The name and qualifications of the surveyor who will perform the work.
 - 3. The names and qualifications of the shoring welders, if used.
- D. Submit a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.
- E. Submit detailed locations and sizes of all shafts, including shoring, storage areas, and groundwater control, if used.
- F. Submit a shaft construction work plan including the following:

1. A detailed description of the shaft construction equipment and procedures to be employed.
 2. A schedule for shaft work identifying all major construction activities as independent items.
 3. Muck handling, separation, transport, and disposal equipment and procedures including the location of muck disposal sites.
- G. Provide shaft shop drawings and design calculations stamped and signed by a Professional Engineer licensed in the State of Colorado.
1. Provide design calculations that clearly disclose assumptions made, criteria followed, and stress values used for the proposed materials.
 2. Furnish design references acceptable to the Engineer substantiating appropriateness of design assumptions, criteria and stress values.
- H. Submit shop drawings and calculations, including:
1. Shoring design calculations and detailed drawings showing means for safe and stable excavations stamped by a Professional Engineer registered in the State of Colorado. The calculations for Launch Shaft shoring shall include the estimated jacking forces transmitted through the thrust block. The drawings shall also show details of the following:
 - a. Removal or abandonment of the shaft shoring.
 - b. Details on ground support and sealing around utility penetrations.
 - c. The location of the jacking pipe entry and exit seals, if required. Detailed description of the proposed launching and receiving eyes through the support system indicating the ability to prevent water and soil from entering the excavation through the shafts.
 - d. Methods for filling or sealing seepage paths or voids that form around the shafts.
 2. Manufacture's descriptive product data, current specifications, and installation instructions for materials or systems proposed for the work of this section.
 3. Calculations shall account for the following:

- a. The required setback for heavy equipment operations during installation of shoring and during construction operations.
 - b. The influence of jacking loads on the shoring.
- I. Submit the following to the Engineer during construction within the specified time restrictions:
 - 1. The daily logs shall have field logs submitted to the Engineer within one working day of excavation. As a minimum, the logs shall include:
 - a. The depth of excavation at each shaft.
 - b. The number of people on the crew by craft.
 - c. Method of excavation.
 - d. Shaft support installed.
 - e. Description of the soils encountered, and position of different soil layers.
 - f. Grouting records if used.
 - g. Groundwater inflow rate and/or dewatering pumping rate at each shaft.
 - h. Monitoring, instrumentation and control including survey records.
 - i. Any unusual conditions, breakdowns, and delays.
 - 2. Results of all instrumentation readings and monitoring including but not limited to ground movements specified in Section 31 09 13.
- J. Postconstruction Submittals:
 - 1. Record of what shaft support elements remain in the ground with location and top elevation.

PART 2 - PRODUCTS

2.01. MATERIALS:

- A. The Contractor shall determine and provide the materials necessary to construct the shafts.
- B. Contractor is responsible for the selection and adherence to the Contract Specifications for the materials used for shaft construction.

PART 3 - EXECUTION

3.01. GENERAL:

- A. A written notice shall be provided to the Engineer not less than one week before beginning shoring work.
- B. Should field conditions prevent installation of shafts at the approved location, obtain prior acceptance from the Engineer for new location.
- C. Where excavations are undertaken near any structure or facility including but not limited to buildings, railroad, highway, streets, or utility, the construction shall not damage, impair, or interfere with the operation of the structure or facility.
- D. At shaft locations where utility conflicts may exist, construction shall be planned accordingly to support and/or move affected utilities.

3.02. MAINTENANCE:

- A. The Contractor shall always keep the site clean and tidy. Site improvements shall be protected from damage or becoming soiled through suitable temporary covering.
- B. Upon completion of work, all waste shall be removed from the site and the site restored to as near its original condition as possible. Any remnants of grout that may have splattered on improvements shall be completely removed.
- C. The Contractor is fully responsible for maintaining and repairing all excavations and support.
- D. Where loss of soil occurs, plug gaps in shoring and replace lost soil.

- E. Contractor shall follow Specification 31 09 13 Geotechnical Instrumentation and Monitoring, for reporting and contingent actions.

3.03. INSTALLATION AND REMOVAL:

- A. The shafts shall be constructed to withstand all imposed loads, including groundwater and saturated soil, dynamic loads from equipment and surcharge loads from materials and traffic. Shaft design shall consider special framing, bracing or shoring required around trenchless operation, pipe “eyes” and other penetrations.
- B. Verify locations of known or suspected underground utilities by potholing prior to placing temporary shafts.
- C. The ground surface near shafts shall be graded to prevent surface water from entering the excavation.
- D. The locations of the launching and receiving shafts shown on the Construction Drawings are for graphical purposes. Final shaft size and configuration is the Contractors’ choice.
- E. The excavations for the shafts shall be shored to safeguard existing substructures and surface improvements and to ensure against ground movement near the thrust blocks.
- F. Any interfering utilities shown on the Construction Drawings within launching and receiving shafts shall be relocated or supported in place at the Contractor’s expense, if approved by utility owner. The Contractor shall be responsible for designing support for utilities left in place where details are not provided in the Construction Drawings.
- G. Control ground settlement or heave to the limits specified in Section 31 09 13. Repair damage resulting from surface deformation caused by shaft excavation and dewatering at no additional cost to the Owner.
- H. Except for concrete encased soldier piles, slurry walls, liner plate, and similar shoring systems, remove shoring at the completion of the work. Select shoring system and method of removal which shall minimize soil that sticks to shoring, creating large voids and causing settlement. To prevent settlement caused by pulling shoring fill voids with sand, pea gravel, or pressure injected grout. Pressure preservative treated wood lagging may be left in place, if acceptable to the Owner.

- I. Shoring systems that retain earth on which the support or stability of existing structures or utilities is dependent shall be left in place at the completion of the work. Cut off piles at elevations directed by the Engineer.
- J. Sheet piles, trench boxes, slide rail systems and/or soldier piles in the shoring system should be removed entirely upon completion of the excavation backfill at the Contractor's expense if approved by the Engineer. Other systems shall have shaft elements to a minimum of 10 feet below the ground surface.
- K. The Contractor shall always maintain clean working conditions inside the shafts. All excavated soil, slush, grout spills, ponded water and other material not required for the work shall be removed from the excavation in a timely manner.
- L. The Contractor shall transport and dispose of all excess excavated materials properly away from the construction site in such a fashion that trucks and other vehicles do not create a dirt nuisance on roads and pathways. Contractor shall secure the required permits and promptly remove and dispose of any spillage. The Contractor shall dispose of muck removed from work area excavations in accordance with all applicable permits, and regulatory requirements.
- M. After completion of tunneling work, the Contractor shall backfill the shafts in accordance with Specification 31 23 43.
- N. Support all faces of shaft excavations and protect structures and improvements in vicinity of excavations from damage due to settlement or movement of soils, including vibrations on sensitive soils and changes in groundwater level caused by such excavations and related operations.
 - 1. Where sheet piling is used, use interlocking type sheets. The sheet piles shall be continuous and driven in interlock. If the bottom of the excavation is located below the water table, use "thumb and finger" type interlock.
 - 2. Provide packing between soil retaining members, such as sheet piles and wales and similar members, when the gap exceeds ½-inch before the members are loaded.

3.04. WELDING REQUIREMENTS:

- A. Perform all welding in accordance with requirements for shielded metal arc welding in accordance with AWS D1.1.

3.05. SEQUENCING:

- A. Do not begin work on shoring or shaft excavation until submittals have been accepted by the Engineer and until materials necessary for installation are onsite.
- B. Do not begin shaft excavation until all geotechnical instrumentation within 50 feet of the shaft as indicated on the Construction Drawings have been installed and surveyed as specified.

3.06. CLEANUP AND RESTORATION:

- A. Remove all equipment, unused materials, and debris from the site at the end of the job. Restoration shall follow construction as the work progresses and shall be completed as soon as possible. Restore and repair any damage resulting from surface settlement caused by the work. Any property or improvements damaged or destroyed, shall be restored to a condition equal to or better than existing prior to construction at no additional cost to the Owner. Restoration shall be completed immediately if a third party or the Owner are inconvenienced by the damage, and in no case later than 30 days after the damage is discovered. This provision for restoration shall include all property which was affected by the construction operations.
- B. At the end of every construction day, construction equipment and materials shall be removed as far from operating railroad tracks as possible (minimum 25 ft from centerline).

END OF SECTION

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SECTION 32 31 26

BARBED WIRE FENCES AND STEEL GATES

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials and installation of barbed wire fence with steel or wood posts and fabricated steel gates.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's descriptive literature and drawings of fence and gate installation.
- C. Submit manufacturer's certificate or original shipping tags showing compliance with cited U.S. Federal and ASTM specifications.

PART 2 - MATERIALS

2.01. BARBED WIRE

- A. At a minimum, barbed wire shall be four twisted 12-1/2-gauge steel wires, 0.80-ounce-per-square-foot zinc coating, 4-point round-shape barbs 5 inches apart.
- B. Barbed wire shall conform to the requirements of ASTM A121 with Class 3 coating.

2.02. STEEL POSTS

- A. Steel posts and accessories shall be in accordance with ASTM A702, galvanized. Height above grade shall be per the Construction Drawings.
- B. Fittings, hardware, and other appurtenances not specifically covered by the Construction Drawings or Specifications shall be standard commercial grade.

2.03. WOOD POSTS

- A. Wood posts and braces shall be pressure treated, straight, sound, and in accordance with ASTM F537, sized to match existing fence posts.

- B. Wood posts shall be of pine, fir, spruce, cedar, aspen, American elm, eastern cottonwood, or ash.

2.04. ACCESSORIES

- A. Brace wire and loops shall be 12.5-gauge smooth galvanized wire. Staples shall be 1 1/2 inches long and made of No. 9 gauge galvanized wire.

2.05. TUBULAR GATES

- A. Tubular gates shall conform to the following:
 - 1. Provide standard 16-foot-wide, 50- to 52-inch height, 6-bar, with two vertical braces. Construct of 2-inch-diameter, 16-gauge galvanized steel tubing with Z-bar vertical supports. Provide 5-inch radius rolled top corners.
 - 2. Joints shall be mitered before welding or shall be continuous welded saddle joints.
 - 3. Provide welded positive lock chain, 30 inches long, 3-1/16-inch minimum with slot latching system and padlock.
 - 4. Provide fixed hinges with 3/4-inch minimum diameter threaded bolt with washers and nuts for wood post mounting.
 - 5. Provide 7-inch-diameter rubber-tired gate wheel mounted on swing end of gate.

2.06. CONCRETE FOR POST FOOTINGS

- A. Five, 94-pound sacks of Portland cement per cubic yard. Do not use accelerating admixtures.

PART 3 - EXECUTION

3.01. PREPARATION FOR INSTALLATION

- A. Clear the line of the fence and dispose of resulting material.

3.02. SETTING WOOD AND STEEL POSTS

- A. Install posts in accordance with ASTM F537, Section 11, except as modified herein.

- B. Space line posts uniformly at maximum intervals of 8 to 10 feet between posts.
- C. Excavate holes for posts to the line and depth shown on the Construction Drawings and of sufficient size to permit adequate compaction of the backfill around the post. For posts set in concrete, excavate posthole so concrete will be 3 inches below and around posts.
- D. Set corner posts and support posts, and securely brace and wire before setting the intermediate posts. For posts set in concrete, posts shall be held in position by secure bracing until concrete has set sufficiently to hold posts. Materials shall not be installed on posts set in concrete or stress placed on bracing until concrete has sufficiently set to withstand the stress.
- E. Set posts plumb to within 1/4 inch of the post's vertical centerline. If not set in concrete, place the backfill around the posts in thin layers and thoroughly compact by tamping. If set in concrete, fill postholes with concrete to 2 inches above finish grade and crown to slope away from post. If metal posts are used for the posts, drive with an approved mechanical device.
- F. Use brace wire consisting of 2 complete loops of galvanized wire. Twist the loops both above and below the brace post until tight. Draw barbed wire taut with an approved mechanical device and securely fasten to each post with fence staple or approved wire clip. Loop the wire around the end and corner posts and fasten with sufficient staples to anchor the wire securely.

3.03. INSTALLING BARBED WIRE ON POSTS

- A. Place the barbed wire by securing one end and then applying sufficient tension to remove slack before making attachments at the next post. Tighten the barbed wire to provide a smooth uniform appearance free from sag.
- B. Mount wires to match adjacent existing barb wire fence.

3.04. INSTALLING GATES

- A. Install gates plumb and level in the locations shown on the Construction Drawings.
- B. Once gate is installed, coordinate with the Owner on lock installation.

END OF SECTION

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SECTION 32 90 10

PROJECT PREPARATION, EXECUTION, AND RESTORATION

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This Section describes Project requirements prior to construction mobilization as well as requirements for site preparation, site maintenance, and site restoration. The Work covered under this Section includes activities required prior to construction, during construction, and after construction to ensure site readiness, environmental protection, erosion and sediment control, cleaning, and final site restoration.

1.02. REFERENCE STANDARDS / DOCUMENTS

- A. ASTM International (ASTM):
 - 1. D638, Standard Test Method for Tensile Properties of Plastics.
 - 2. D3776/D3776M, Standard Test Methods for Mass Per Unit Area (Weight) of Fabric.
 - 3. D4355, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in Xenon Arc Type Apparatus.
 - 4. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
- B. NFPA 241 is the National Fire Protection Association standard titled "Standard for Safeguarding Construction, Alteration, and Demolition Operations.
- C. ANSI/ISEA Z308.1 is the American National Standard - minimum requirements for workplace first aid kits and their supplies.
- D. Occupational Safety and Health Administration (OSHA) Applicable Standards.
- E. Wherever reference is made in this Section to the LCRARS, such reference shall be understood to mean the "Larimer County Rural Area Road Standard", latest edition.

- F. Wherever reference is made in this Section to the LCROWCP, such reference shall be understood to mean the provisions provided in the Larimer County Right-of-Way Construction Permit.

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.

- B. Submittals:

1. 1041 Conditions of Approval Submittals

- a. The Larimer County 1041 Permit that Thornton obtained for the Project dictates Conditions of Approval that must be met before construction activities can begin, including contractor mobilization to the site. Larimer County will issue a Development Construction Permit to the Owner after the Conditions of Approval have been met.
- b. The Contractor shall submit the following plans and permits so the Owner can obtain the Larimer County Development Construction Permit. Reference Specification Section 01 41 10 and 1041 Compliance Matrix and Contractor Requirements.
 - (1) The first page of each submittal document shall indicate in red text the Conditions of Approval Number the submittal document is intended to meet.

2. Fugitive Dust, Air Emissions, and Air Quality Management Plan

- a. In accordance with Larimer County 1041 Permit Condition of Approval Nos. 16, 17, 18, and 80, Contractor to develop, submit, and implement a plan to mitigate against fugitive dust and other emissions to protect local air quality.
- b. The plan shall ensure that:
 - (1) No off-site transport of visible emissions from disturbed areas, dirt access roads, stockpiles, and haul trucks.
 - (2) A water truck is on-site during operating hours and non-operating hours including Sundays to regularly apply water to active

construction areas, dirt access roads, stockpiles, and other areas of disturbed soil to prevent visible emissions from the corridor active construction areas.

- (3) No earthwork takes place during days where high winds of 30 miles per hour or greater are occurring. However, Contractor's water truck shall be in operation.
- (4) Speed limit signs are posted in active construction areas restricting speeds to 15 miles per hour.
- (5) Loaded haul trucks are covered during transport and storage to prevent visible emissions and the blowing, dropping, sifting, or leaking of materials is prevented.
- (6) Sediment deposition due to project activities is promptly removed from public roads and rights-of-way.
- (7) Drivers and operators unload truck beds and loader or excavator buckets slowly and that drop heights of materials is as low as possible.
- (8) The height of temporary soil stockpiles are kept at a height of 10 feet or lower so that water trucks or manual hoses can be used to apply water to the entire stockpile.
- (9) Measures to ensure that work sites, temporary staging areas, field trailer areas, finished construction areas and areas where workers gather for breaks are maintained litter-free and supplied with lidded trash enclosures/dumpsters that can withstand water and wind.
- (10) Measures to control, mitigate, and reduce air quality impacts and exposures from odor / fume producing equipment and activities such as generators and associated power equipment.

3. Noise Mitigation Plan

- a. In accordance with Larimer County 1041 Permit Condition of Approval Nos. 19, 21 and 22, Contractor shall develop, submit, and implement a Noise Mitigation Plan.

- b. The plan shall document and ensure that:
- (1) Work is performed on the days and within the hours allowed by the Contract Documents.
 - (a) The plan shall note that if work is to be performed outside of the specified hours and days, documents supporting a deviation shall be submitted to Larimer County 72 hours in advance for evaluation and approval by the Larimer County Health Department, Planning, and Engineering.
 - (2) Construction complies with the Larimer County Noise Ordinance. If the Contractor needs an exception to the Noise Ordinance, Contractor to include exemption justification information and requests in the Noise Mitigation Plan for Larimer County approval.
 - (3) Procedures to control / manage low frequency sound and vibrations.
 - (4) A contractor point of contact is listed that can address noise complaints.
 - (5) Equipment is serviced and maintained to manufacturer's specifications.
 - (6) Appropriate equipment mufflers are used.
 - (7) When equipment is not actively operating or moving, motors are turned to idle.
 - (8) Equipment and material deliveries are staged / scheduled such that long lines of idling trucks do not form.
 - (9) Trucks and equipment follow efficient travel paths and movement corridors to minimize backup and or circling.
 - (10) Sound attenuating / quiet pumps and generators are used.
 - (11) Trucks and equipment use white noise back beepers along the construction corridor.
 - (12) Temporary and/or portable sound barriers are installed in locations where loud operations or equipment use is anticipated.

4. Emergency Utility Plan

- a. In accordance with Larimer County 1041 Permit Condition of Approval No. 28, Contractor shall develop, submit, and implement an Emergency Utility Plan.
- b. The plan shall document and ensure that:
 - (1) The Contractor understands responsibilities associated with existing utility protection.
 - (2) Utility notification and locate procedures are following in accordance with Specification Sections 02 01 20 and State of Colorado utility locate law.
 - (3) All emergency utility contacts are known, listed, and kept on site including but not limited to gas, electric, water, irrigation, and communication utilities.
 - (4) Plans and procedures to address impacts associated with the types of utilities that could be encountered and the materials needed for quick repair and utility restoration. The plan shall include how the Contractor would secure repair materials in a timely manner.
 - (5) Plans and procedures to provide temporary utilities or alternative accommodations should public or private utilities be impacted.

5. Initial and Final County Roads Inventory

- a. In accordance with Larimer County 1041 Permit Condition of Approval Nos. 37 and 47, Contractor shall develop, submit, and implement an Initial and Final County Roads Inventory.
- b. Contractor shall not use any Larimer County gravel roads other than:
 - (1) Larimer County Road No. 56 between State Highway 1 and the BNSF Railroad.
 - (2) Larimer County Road No. 54 between Giddings Road (LCR 9) and Segment F.1's easterly construction limits.
- c. The plan inventory shall document:

- (1) Roads intended to be used for construction traffic including daily use as well as for deliveries of material and equipment and material disposal (Haul Routes).
- (2) Pre-construction conditions of all roads used – Reference Specification Section 01 32 33.
- (3) Work conducted to return all roads used to pre-construction conditions. This work shall be documented and included in the Final County Roads Inventory.

6. Road Maintenance and Repair Plan

- a. In accordance with Larimer County 1041 Permit Condition of Approval Nos. 37 and 47, Contractor shall develop, submit, and implement a Road Maintenance and Repair Plan.
- b. Contractor shall not use any Larimer County gravel roads other than:
 - (1) Larimer County Road No. 56 between State Highway 1 and the BNSF Railroad.
 - (2) Larimer County Road No. 54 between Giddings Road (LCR 9) and Segment F.1's easterly construction limits.
 - (3) Should the maintenance, repair, or restoration of Larimer County Roads No. 11 or No. 13 outside the limits of construction be required as a result of Contractor use, the Contractor shall be fully responsible for all costs and efforts associated with dust control, maintenance, repair, and restoration.
- c. The maintenance and repair plan shall document:
 - (1) How often the Contractor will evaluate the conditions of roads and how the conditions will be documented.
 - (2) How decisions will be made in coordination with Larimer County on the maintenance needed and how repairs will be made including time needed to make repairs.

- (3) If it has been determined by the Larimer County Engineer that there has been an acceleration in deterioration of the roadway surface during or after construction as a result of construction traffic, equipment, or hauling, the Contractor will be required to restore the roadways to their prior condition. This may include the need for regrading and resurfacing.

7. Traffic Control and Management Plan

- a. In accordance with Larimer County 1041 Permit Condition of Approval Nos. 44 and 45, Contractor shall develop, submit, and implement a Traffic Control and Management Plan.
- b. At a minimum the plan shall include and document:
 - (1) Certified traffic control plans
 - (2) Proposed road or lane closures and associated detours.
 - (3) Proposed road or lane closure time frames
 - (4) Traffic control devices and personnel including warning signs, flaggers, traffic control supervisors, message boards, timed one-way, traffic signals.
 - (5) Proposed measures to ensure access to private properties by residences, school buses, and emergency responders.
 - (6) Process for addressing and responding to accidents or public complaints should they occur.
 - (7) Reference Specification Sections 01 41 10 and 31 09 13.

8. Site Specific Stormwater Management, Erosion and Sediment Control Plan

- a. In accordance with Larimer County 1041 Permit Condition of Approval Nos. 2, 49, and 63, Contractor shall develop, submit, and implement a Stormwater Management, Erosion and Sediment Control Plan (SWMP) to prevent or minimize pollutants in stormwater runoff from construction activities.

- b. The Plan shall follow all the applicable requirements defined in the Colorado Department of Health and Environment (CDPHE) CDPS General Permit for Stormwater Discharges Associated with Construction Activity (Permit No. COR-40000), Section C – Stormwater Management Plan (SWMP) - Contents.
- c. At a minimum the plan shall include and document:
 - (1) Measures and procedures required by Project permits and by Federal, State, and local laws and regulations regarding prevention of water pollution.
 - (2) Grading, erosion, and sedimentation control plan and procedures.
 - (3) Schedule for implementation of Initial, Interim, and Final grading, erosion, and sedimentation control measures. Contractor shall append a copy of the proposed project schedule to the Plan and shall keep the Plan updated to reflect conditions in the field.
 - (4) Method for placement of soil stabilization seed and additives.
 - (5) Calculations and implementation measures for all Temporary Diversion Channels and Temporary Stream Crossings.
 - (6) Proposed stormwater protection products, suppliers, and methods of installation for the following:
 - (a) Surface Roughening
 - (b) Temporary/Permanent Seeding
 - (c) Mulching
 - (d) Check Dam
 - (e) Silt Fence
 - (f) Erosion Control Blanket
 - (g) Rock Sock
 - (h) Inlet Protection

- (i) Concrete Washout Area
 - (j) Stockpile Management
 - (k) Construction Fence
 - (l) Vehicle Tracking Control
 - (m) Stabilized Staging Area
 - (n) Dewatering Operations
 - (o) Good Housekeeping
- (7) How protection measures will be monitored, repaired or replaced.
- (8) Confirmation that water pollution control measures comply with Larimer County, Owner, and CDPHE requirements. The plan will be modified as needed throughout the Project. Each change does not require approval. It is the Contractor's responsibility to update and maintain the plan as needed to meet permit and contract documents requirements.
- (9) Soil stockpile stabilization and soil handling measures including proposed stockpile locations, perimeter controls, stabilization methods, access points, and written acknowledgement that required stabilization and soils handling requirements were reviewed and understood.

9. BMP Plan

- a. In accordance with Larimer County 1041 Permit Condition of Approval Nos. 2, 51, and 66 Contractor shall develop, submit, and have approved a Plan describing best management practices (BMPs) to be implemented for construction that affects developed, rural, wetland and riparian land areas or stream crossings. Such documentation is to include, but not be limited to, preconstruction and construction BMPs relating to surface water, erosion and sediment control and prevention; groundwater considerations and protection; topsoil conservation and restoration and vegetation / revegetation considerations. Lastly, the document shall address post-

construction BMPs and monitoring requirements and plans for adaptive management if necessary.

- b. Groundwater considerations include, but may not be limited to, the installation of concrete cutoff walls (trench plugs).

10. Exterior Lighting Management Plan

- a. In accordance with Larimer County 1041 Permit Condition of Approval No. 81, Contractor shall develop, submit, and implement an Exterior Lighting Management Plan meeting Larimer County regulations.
- b. At a minimum the plan shall include and document:
 - (1) The time of year and time of day that temporary exterior lighting is proposed and requested.
 - (2) How the temporary exterior lighting will not create light pollution and disturb nearby residents or the traveling public.

11. Pre-Project Video

- a. In accordance with Larimer County 1041 Permit Condition of Approval No. 32, Contractor shall produce and submit a pre-project video that captures existing conditions of the proposed water line installation corridor in and near the existing ROW.

12. Permit Copies

- a. Contractor shall provide copies of permits and approvals for construction as required by the Contract Documents, Larimer County Develop Construction Permit approval process, and applicable federal, state, and local laws and regulations. Reference Specification Section 01 41 10. The Larimer County Development Construction Permit application requires submission of the CDPHE Stormwater Permit and other permits required for work in Larimer County ROW before issuance of the Development Construction Permit.

13. Contractor's Parking, Staging, Storage, and Site Security Plan(s)

14. Method for placement of soil stabilization seed and additives.

15. Proposed seed and shrub mixes and plantings, and proposed suppliers.
16. Proposed fertilizers, soil amendments, or conditioners.
17. Pre- and Post-Construction Topographic Surveys
 - a. Contractor to submit pre-construction survey of existing topography, drainage culverts, irrigation ditches, and access driveways to be used to confirm that restoration was returned to pre-construction lines and grades after final restoration.
 - b. The pre-construction survey shall be submitted a minimum of 7 days prior to the commencement of any construction activities or land disturbance. The post-construction surveys shall be provided 14 days after completing work on individual properties or within road right-of-ways.
 - c. The pre- and post-surveys shall:
 - (1) The survey shall be submitted electronically in AutoCAD Civil3D format, be accompanied by points lists in ASCII text file format, and be useable for 3-dimensional evaluation.
 - (2) Contain an accuracy to 0.1 foot.
 - (3) Be developed using Project coordinates and shall be referenced to the Project base lines and benchmarks.
 - (4) Result in electronic mapping files with sufficient accuracy for reproduction and use as base maps at a scale of one-inch = 40-feet horizontal and 1-foot contour intervals as required for National Map Accuracy Standards.
 - (5) Shall be prepared, sealed, and signed by a Professional Land Surveyor registered in the State of Colorado.

PART 2 - PRODUCTS

2.01. PROJECT SIGNS

- A. The Owner is procuring six (6) metal program / project signs for use on the project, 6 feet x 4 feet in dimensions. The following are to be provided by the Contractor:

1. Receive and mount the project signs where they can be displayed and moved as necessary during the Project duration. Sign mounting shall comply with the approved sign permit.
2. Provide wooden, steel, or aluminum mounts, Unistrut, mounting hardware, legs / feet.
3. Provide all materials and labor required to mount the provided signs and coordinate with the Owner on the location, erection, and movement of project signs during the course of the Project. Location of project signs to be approved by the Construction Manager.
4. Contractor shall obtain a 'Temporary Construction and Project Marketing' Permit for the installation of project signs.

2.02. CONTRACTOR FIELD OFFICE

- A. See Segment F.2 Specification 01 35 13.

2.03. OWNER FIELD OFFICE

- A. See Segment F.2 Specification 01 35 13.

2.04. SILT FENCE

- A. Geotextile:

1. In accordance with requirements of Table No. 1.
2. Manufacturers and Products:
 - a. Mirafi; 100x.
 - b. Geotext; 915sc.

Table No. 1		
Physical Property	Required Value	Test Method
Weight, oz/sq yd, min.	4	ASTM D3776/D3776M
Equivalent Opening Size, max.	50-70	U.S. Standard Sieve
Grab Tensile Strength, lb, min.	160	ASTM D4632
Ultraviolet Radiation Resistance, % Strength Retention	70	ASTM D4355

- B. Support Posts: As recommended by manufacturer of geotextile.
- C. Fasteners: Heavy-duty wire staples at least 1 inch long, tie wires, or hog rings, as recommended by manufacturer of geotextile.

2.05. CONSTRUCTION FENCE

- A. Fabric: Ultraviolet stabilized polyethylene, polypropylene, or nylon filaments woven into uniform pattern, with distinct and measurable openings.
- B. Minimum Physical Qualities:
 - 1. Tensile Yield: Average 2,000 pounds per 4-foot width; ASTM D638.
 - 2. Ultimate Tensile Yield: Average 2,900 pounds per 4-foot width; ASTM D638.
 - 3. Elongation at Break: Greater than 1,000 percent; ASTM D638.
 - 4. Chemical Resistance: Inert to most chemicals and acids.
- C. Color: Yellow or orange.
- D. Height: Three feet.
- E. Material Edges: Finished in order that filaments retain their relative positions under stress.
- F. Posts: Conventional metal "T" or "U" posts.

2.06. EROSION AND SEDIMENT CONTROL BMPS

- A. Refer to the Construction Drawings and Erosion Control Details for BMP requirements.

B. Erosion Control Blanket

1. 100% biodegradable woven bristle coir with no synthetic netting, films, or yarns that could harm wildlife.
2. Functional life shall be a minimum of 4 years.
3. Open weave design to allow seedling emergency and re-seeding through blanket.
4. Dry Tensile Strength shall be a minimum of 1,900 lbs/ft machine direction and minimum of 1,400 lbs/ft cross direction per ASTM D4595
5. Wet Tensile Strength shall be a minimum of 1,200 lbs/ft machine direction and minimum of 750 lbs/ft cross direction per ASTM D4595
6. Thickness shall be a minimum of 0.35" per ASTM D5199
7. UV stability shall be a minimum of 500 hrs per ASTM D4355
8. Open Area shall be 35-40%.
9. Earthshield Natural, RollMax BioNet, KoirMat, or equal.

2.07. TOPSOIL

- A. Topsoil shall be obtained from topsoil stockpiled from required stripping operations in accordance with Subsection 3.02.

2.08. HYDROSEED FOR TEMPORARY STABILIZATION

- A. Wood-fiber hydro mulch with sterile rye combined with water, starter fertilizer, and tackifier.

2.09. CRIMPED MULCH

- A. Weed-free wheat or oat straw.

2.10. TACKIFIER

- A. EM-TACK, or approved alternative.

2.11. SEED MIXES AND PLANTING MATERIALS

- A. Refer to the Construction Drawings for seed mixes and planting species.
- B. Seeds shall be weed free and delivered to the site in bags or containers that are unopened and clearly labeled.
- C. If seed mix or planting species vary from what is indicated on the Drawings, Contractor shall actively work with the Construction Manager to ensure that property owners and Larimer County have approved the project seed mixes and plant species.
- D. Contractor shall work with Construction Manager and Owner in the performance of a seed lot review.
- E. Trees in ball and burlap will be at least 2 inches in caliper.
- F. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix Conditions of Approval No. 69 included with the Project Manual.

2.12. PERMANENT ACCESS

- A. CDOT Class 5 or 6 aggregate base course.

2.13. GRAVEL ROADWAYS

- A. Refer to the Construction Drawings for road materials.

PART 3 - EXECUTION

3.01. PRE-CONSTRUCTION PROJECT PREPARATION

A. Mobilization

1. Mobilization shall include, but not be limited to, these principal items:
 - a. Mobilization can only take place after all required Federal, State, and Local permits and approvals have been secured.
 - b. Mobilization can only take place after Contractor and Construction Manager have met and reviewed the Work / Phase Plan with Poudre Fire and Rescue, the Larimer County Sheriff's Office, and the Poudre Valley School District.

- c. Moving Contractor's equipment required for first month operations onto Site.
 - d. Arranging for and erecting staging and storage yards.
 - e. Arranging for and erection of Contractor's and Owner's temporary construction offices including power, communications, onsite sanitary facilities and potable water facilities as specified and as required by Laws and Regulations, and governing agencies.
 - f. Posting OSHA required notices and the establishment of safety programs and procedures.
 - g. Having Contractor's superintendent at site full time.
2. Limit all construction activities and temporary facilities to areas shown on drawings. If additional area is needed, the Contractor shall notify the Owner ahead of time of the additional area location and anticipated duration of need so the Owner can confirm with Larimer County that this additional area and need will be in conformance with the 1041 Conditions of Approval. If additional area is approved by Larimer County, it is the responsibility of the Contractor to secure the area and provide access to the area for the duration of Project. Contractor shall also provide property owner authorization for the use of additional areas.

B. Temporary Utilities

- 1. Power: No electric power is available at the Site. Cost of electric power will be borne by Contractor.
- 2. Lighting: Provide temporary lighting, as required, to meet applicable safety requirements to allow erection, application, or installation of materials and equipment, and observation or inspection of the Work.
- 3. Water: The Contractor is responsible for securing construction water. Provide and maintain an adequate supply of potable water for domestic consumption by Contractor Owner, and Construction Manager personnel.
- 4. Sanitary and Personnel Facilities: Provide and maintain facilities for Contractor's employees, Subcontractors, and other onsite employees. Service, clean, and maintain facilities and enclosures.

5. Telephone Service: Provide emergency telephone service at the Contractor's field office, or by mobile telephone, for use by Contractor personnel and others performing work or furnishing services at the Site.
6. Fire Protection: Furnish and maintain on site adequate firefighting equipment capable of extinguishing incipient fires. Comply with applicable parts of the National Fire Protection Association Standard (NFPA) 241.

C. Erosion and Sediment Control BMP Installation

1. Install BMPs prior to work involving site clearing, stripping, and excavation.
2. Contractor shall be responsible for phasing Work, including development of proposed stockpile areas and installation of temporary erosion control devices, ditches, or other facilities.
3. Areas within the limits of construction may be temporarily disturbed to provide satisfactory working, staging, and administrative areas. Preparation of these areas shall be in accordance with other requirements contained within Specifications and completed in a manner to control sediment transport away from area.
4. Silt Fence Installation
 - a. Install silt fence prior to starting earth disturbing activities.
 - b. Install silt fence in accordance with manufacturer's instructions.
 - c. Install geotextile in one piece, or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench. Take precaution not to puncture geotextile during installation.
 - d. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.
 - e. Securely fasten geotextile to each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.
 - f. When joints are necessary, splice geotextile together only at support post, with a minimum 6-inch overlap, and securely fasten both ends to support post.

- g. Geotextile shall not extend more than 34 inches above ground surface. Securely fasten to upslope side of each support post using ties. Do not staple geotextile to existing trees.
- h. Remove only after upslope area has been permanently stabilized.

D. Pre-Construction Weed Control

- 1. As directed by the Construction Manager, Contractor shall apply pre-construction weed control in select areas to be identified by the Construction Manager. Weed control will involve spraying a Larimer County-approved weed control product at select times in the Spring and Fall prior to topsoil disturbance. The weed control product should be applicable to controlling Leafy Spurge (*Euphorbia esula*), Canada Thistle (*Cirsium arvense*), Field Bindweed (*Convolvulus arvensis*), Scotch Thistle (*Onopordum acanthium*), Cheatgrass (*Bromus tectorum*), and Hoary Cress (whitetop) (*Cardaria draba*).

E. Access Roads and Detours

- 1. All access locations and detours on Larimer County roads shall be approved by Larimer County and comply with Larimer County regulations.
- 2. Construct access roads within easements or Project limits. Alignments for new routes shall be approved by the Construction Manager.
- 3. Maintain drainage ways. Install and maintain culverts to allow water to flow beneath access roads. Provide corrosion-resistant culvert pipe of adequate strength to resist construction loads.
- 4. Provide vehicle tracking control pad (gravel, crushed rock, or other stabilization material) to permit access by all motor vehicles at all times.
- 5. Maintain road grade and crown to eliminate potholes, rutting, and other irregularities that restrict access.
- 6. Where access road crosses existing fences, install and maintain gates at right of way limits.

F. Parking Areas

1. Control vehicular parking to prevent interfering with public traffic or parking, access by emergency vehicles, Owner and Construction Manager's operations, or construction operations.
2. Provide parking facilities for personnel working on, or visiting, the Project. No employee or equipment parking will be permitted within road rights-of-way or on existing private drives and roads.

G. Storage Yards and Buildings

1. Temporary Storage Yards: Construct temporary storage yards for storage of products that are not subject to damage by weather conditions.
2. Temporary Storage Buildings:
 - a. Provide environmental control systems that meet recommendations of manufacturers of equipment and materials stored.
 - b. Arrange or partition to provide security of contents and ready access for inspection and inventory.
 - c. Store combustible materials (paints, solvents, fuels) in a well-ventilated and remote building meeting safety standards.
 - d. Do not locate storage buildings within the 100-year floodplain.

H. Aquatic Hitchhiker Prevention Requirements:

1. If heavy equipment is used for the project that was previously working in another stream, river, lake, pond, or wetland within 10 days of working on this project, one of the following disinfection practices is required prior to construction to prevent the spread of invasive aquatic species (including but not limited to Eurasian water milfoil, zebra mussel, quagga mussel, and New Zealand mud snails) into the drainages. These practices are also necessary after project completion, prior to this equipment being used in another stream, river, lake, pond, or wetland, for the same purpose. Contractor shall provide a formal written disinfection certification before equipment is used and Thornton will provide the certificate to Larimer County.
2. Remove all mud and debris from equipment (tracks, turrets, buckets, drags, teeth, etc.) and spray/soak equipment with a solution of commercial grade

quaternary ammonium disinfectant compound containing at least 8.0 percent active ingredient diluted in solution to achieve at least 0.8 percent concentration. Specifically, a 1:15 solution of Quat 4 or super HDQ Neutral Institutional cleaner and water, can be used for effective treatment. Treated equipment should be kept moist for at least 10 minutes, managing rinsate as a solid waste in accordance with local, county, state, or federal regulations.

3. Remove all mud and debris from equipment (tracks, turrets, buckets, drags, teeth, etc.) and spray/soak equipment with water hotter than 140 degrees Fahrenheit for at least 10 minutes.
4. Clean hand tools, boots, and any other equipment that will be used in the water using one of the above options as well.

I. Noxious Weed Transport Management:

1. In accordance with Larimer County 1041 Permit Condition of Approval No. 70, Contractor to prevent the introduction or spread of noxious weeds.
2. All equipment (e.g., track equipment, rubber tire loaders, and backhoes) shall be cleaned using high-pressure air or water spray before being delivered to the project site to prevent introducing undesirable plants and noxious weeds.
3. The Construction Manager will perform an equipment inspection as part of equipment mobilizations and deliveries.

3.02. CONSTRUCTION EXECUTION AND MAINTENANCE

A. Protection of Work and Property

1. Areas outside the Construction Limits shown on the Drawings shall be protected from damage by the Contractor. Any disturbance of vegetation or native ground outside the Construction Limits shown on the Drawings shall be reclaimed by the Contractor at no additional expense to the Owner.
2. Use of Explosives: No blasting or use of explosives will be allowed onsite.
3. Maintain in continuous service existing gas lines, underground power, telephone or communication cable, water mains, sewers, poles and overhead power, and other utilities encountered with the Work, unless other arrangements satisfactory to the utility owners have been made.

4. Where completion of the Work requires temporary or permanent removal or relocation of existing utility, coordinate activities with utility owner and perform work to their satisfaction.
5. Protect, shore, brace, support, and maintain underground pipes, conduits, drains, and other underground utility construction uncovered or otherwise affected by construction operations.
6. Keep fire hydrants and water control valves free from obstruction and available for use at all times.
7. In areas where Contractor's operations are adjacent to or near a utility, such as gas, telephone, television, electric power, water, sewer, or irrigation system, and such operations may cause damage or inconvenience, suspend operations until arrangements necessary for protection have been made by Contractor.
8. Before exposing a utility, obtain utility owner's permission. Should service of utility be interrupted due to Contractor's operation, notify Construction Manager and utility owner immediately. Cooperate with utility owner in restoring service as promptly as possible and bear costs incurred.
9. Keep Owner and Construction Manager informed of onsite accidents and related claims.
10. Do not impair operation of existing sewer systems. Prevent construction material, pavement, concrete, earth, volatile and corrosive wastes, and other debris from entering sewers, pump stations, or other sewer structures.
11. Maintain original Site drainage wherever possible.

B. Site Security:

1. Provide and maintain temporary security fences as necessary to protect the Work and Contractor-furnished products not yet installed.
2. Protect all Work materials, equipment, and property from loss, theft, damage, and vandalism. Contractor's duty to protect property includes Owner's property.

C. Preservation of Trees, Shrubs, and Other Plant Material

1. Existing trees, shrubbery, and other vegetative material may not be shown in the Drawings. Contractor to inspect the limits of construction with the Construction Manager to observe and document the nature, location, size, and extent of trees to be protected and preserved as shown on the Contract Drawings. Contractor to flag protected trees in a highly visible manner.
2. Contractor shall make sure to save and protect plant materials (trees, shrubbery, and plants) beyond the limits of construction from damage resulting from the work. No filling, excavating, trenching, or stockpiling of materials will be permitted within the drip line of trees designated for protection. The drip line is defined as a circle drawn by extending a line vertically to the ground from the outermost branches of a plant or group of plants. To prevent soil compaction within the drip line area, no equipment will be permitted within this area. Provide temporary barricades around trees to be protected.
3. Cut and remove tree branches only where necessary for construction and gain permission for removal from the Construction Manager. An approved tree sealant shall be applied to treat cuts.
4. In event of damage to bark, trunks, limbs, or roots of trees and plants that are not designated for removal, treat damage by corrective pruning, bark tracing, application of a heavy coating of tree paint, and other accepted horticultural and tree surgery practices. Cover temporarily exposed roots with wet burlap and keep burlap moist until soil is replaced around roots; and water as necessary to maintain health.
5. Dispose of removed trees in a legal manner off the Site.

D. Site Clearing, Grubbing, Stripping, and Soil Management

1. In accordance with Specification Section 01 41 10, Contractor to coordinate with Construction Manager to gain approval for the start of site clearing and grubbing activities.
2. Restrict clearing, grubbing, and stripping limits to within the limits of construction shown on the Contract Drawings.
3. Reserve adequate space within the limits of construction for temporary soil storage and protection so that it can be used during backfilling and restoration.

4. Contractor shall remove and dispose of wood or root matter, including trees, stumps, logs, trunks, roots, or root systems greater than one (1) inch in diameter to a depth of 24-inches below the ground surface and properly dispose of offsite.
5. Remove rocks 3" and larger, tiles, lumps of concrete, trash piles, rubbish, and fencing. Remove all evidence of their presence from the surface and properly dispose of offsite.
6. Protect structures and piping above and below ground, trees, shrubs, and vegetative growth which are not designated for removal or listed for protection.
7. After clearing and grubbing, Contractor shall remove all non-restorative or objectionable material including, but not limited to, organic sod, grass, and grass roots.
8. Remove existing gravel or improved surfaces only to the extent needed to facilitate construction.
9. Contractor shall not burn combustible material. Cleared, grubbed, and stripped material shall be removed from the construction limits and disposed of offsite with the exception of topsoil including wetland soil.
10. Segregated topsoil, root zone material, and upper and lower backfill materials excavated on agricultural properties shall not be used for berms, ramps, or general fill. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix Conditions of Approval No. 68 included with the Project Manual.
11. Do not mix materials across properties, parcels, or agricultural soil management units (MU).
12. Do not strip, place, or traffic topsoil when soil conditions are moist or wet Contractor shall not proceed with work until formal permissions is provided by the Construction Manager.
13. Contractor, Construction Manager, and Owner shall meet to review requirements before any clearing, grubbing, stripping, or soils handling takes place, and clearly delineate the limits of the various soil types.
14. Contractor shall notify Construction Manager a minimum of 3 working days before the following activities take place:

- a. Start of topsoil stripping
 - b. Start of soil zone removals
 - c. Ripping, scarifying, and de-compaction in preparation for soil zone replacements.
 - d. Start of soil zone replacements.
15. The stripping, excavation, stockpiling, and backfilling of soil zone materials shall follow a first out, last in sequence.

E. Stockpiled Soil:

- a. Topsoil, wetland topsoil, root-zone material, upper backfill, lower backfill, and wet backfill shall be carefully segregated and stockpiled separately to prevent mixing. Soil Management Unit 1 (MU-1) has requirements related to upper and lower backfill zones. All other Soil Management Units have one (1) backfill zone. Contractor to reference Section 3.02.G. Topsoil stockpiles shall be placed at the outside edge of the construction corridor. Minimum stockpile separation shall be 10 feet.
- b. Wet backfill shall be segregated into a separate stockpile and shall not be placed in, or immediately beneath, the reconstructed 0-24 inch soil profile.
- c. Protect from erosion by surrounding stockpiles with silt fence.
- d. Stabilize topsoil, root-zone material, and backfill stockpiles if left dormant for more than 14 days with hydroseed applied at a rate of 3,000 pounds per acre with 100 pounds of tackifier per acre.
- e. Wetland topsoil should not be stockpiled for more than 30 days and cannot receive temporary stabilization measures.
- f. Minimum height shall be 4 feet and maximum height shall not exceed 10 feet. Maximum slope shall not exceed 3:1.
- g. Sediment transport and erosion from working stockpiles shall be restricted from moving beyond immediate stockpile areas by construction of temporary toe-of-slope ditches and accompanying silt fences, as necessary.

Keep these temporary facilities in operational condition by regular cleaning, regrading, and maintenance.

- h. Contractor shall closely coordinate the Work with the Construction Manager who will be responsible for developing daily soil handling logs, stockpile identification staking, stockpile tracking logs, and photo / video documentation.
- i. Owner will perform post-construction soil testing on stockpiled topsoil to determine if soil amendments and/or fertilizers need to be incorporated before Contractor performs final seeding / restoration. Contractor to provide Construction Manager with a minimum of 45 calendar days of advanced notice of when topsoil is scheduled to be replaced.
- j. Owner will perform post-construction soil testing on replaced root zone material and topsoil in agricultural areas to determine if soil amendments and/or fertilizers need to be incorporated before Contractor performs final seeding / restoration. Soil testing will take place after final grading is complete. Contractor to provide Construction Manager with a minimum of 45 calendar days of advanced notice of when topsoil is scheduled to be replaced.

F. Stabilization of Placed Soil (Temporary)

- a. On agricultural properties, Contractor shall stabilize placed root zone material if left dormant for more than 14 days between placement and subsequent topsoil placement and preparation. Stabilization shall involve the placement of crimped mulch at a rate of 4,000 pounds of straw mulch per acre (75 lb bail per 800 square feet) with tackifier applied to straw using 100 pounds of tackifier per acre.
- b. On non-agricultural properties, Contractor shall stabilize placed topsoil material if left dormant for more than 14 days between placement and subsequent final seeding / restoration. Stabilization shall involve the placement of crimped mulch at a rate of 4,000 pounds of straw mulch per acre (75 lb bail per 800 square feet) with tackifier applied to straw using 100 pounds of tackifier per acre
- c. Place and maintain soil stabilization over disturbed areas. Maintain until areas are approved for permanent seeding.

G. Soil Management Requirements Summary

1. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix Conditions of Approval No. 9 included with the Project Manual.

Stationing, Soil Type, Management Unit	Requirements
10+00 - 206+34 Upland and Riparian	• Strip, stockpile, and stabilize topsoil as required here within. Assume a topsoil depth of 6", exact depth to be field determined. • In coordination with Construction Manager, adjust stripping and excavation depths as necessary to prevent mixing soil types. • Minimize equipment passes / turning on stripped surface and on placed lifts.
10+00 - 206+34 Wetlands / Waters	• Strip and stockpile wetland soils required here within. Assume a topsoil depth of 10", exact depth to be field determined. • In coordination with Construction Manager, adjust stripping and excavation depths as necessary to prevent mixing soil types. • Minimize equipment passes / turning on stripped surface and on placed lifts. • Do not stockpile wetland soil for more than 30 days. • No soil amendments / fertilizers are to be incorporated. • Contractor to refer to Contract drawings for wetland / water locations.
206+34 – 234+74 MU-1 (4 Zone) Standard Handling	• Strip / stockpile topsoil. Depth of 0-12". • Remove / stockpile root zone material. Depth 12-24". • Remove / stockpile upper backfill zone material. Depth 24-36". • Remove / stockpile lower backfill zone material. Depth below 36". • Contractor shall not strip, traffic, or place soil when free water, pumping or smearing is present, or when rutting exceeds 2 inches. Contractor shall allow drying and the re-scarify/de-compact the affected surface. • Minimize equipment passes / turning on stripped surface and on placed lifts. • Coordinate with Construction Manager on necessary stripping and excavation depths to prevent mixing soil zones. Perform zone control verification every 500 linear feet. • After upper backfill zone is replaced, de-compact / rip to a minimum depth of 12" prior to replacement of root zone material to avoid zone mixing. • After root zone is replaced, de-compact / scarify root zone to a depth of 12" prior to the replacement topsoil placement to avoid zone mixing.

Stationing, Soil Type, Management Unit	Requirements
235+80 – 248+34 MU-2 (3 Zone) Enhanced	• Strip / stockpile topsoil. Depth of 0-8". Use controlled stripping method (e.g., excavator peel) • Remove / stockpile root zone material. Depth 8-24". • Remove / stockpile backfill zone material. Depth below 24". • Contractor shall not strip, traffic, or place soil when free water, pumping or smearing is present, when rutting exceeds 1 inch, or when soil 'balls' adhere to tracks/tires. Contractor shall allow drying and the re-scarify/de-compact the affected surface. • Contractor to obtain approval from Construction Manager that conditions and equipment are acceptable for work. • Minimize equipment passes / turning on stripped surface and on placed lifts. • Coordinate with Construction Manager on necessary stripping and excavation depths to prevent mixing soil zones. Perform zone control verification every 250 linear feet. • After backfill zone is replaced, de-compact / rip to a minimum depth of 12" prior to replacement of root zone material. • After root zone material is replaced, de-compact / scarify to a depth of 12" prior to placement of topsoil to avoid zone mixing.
248+34 – 280+00 MU-3 294+50 – 305+50 MU-5 312+02 – 314+37 MU-7 (3 Zone) Standard	• Strip / stockpile topsoil. Depth 0-12". • Remove / stockpile root zone material. Depth 12-24". • Remove / stockpile backfill zone material. Depth below 24". • Contractor shall not strip, traffic, or place soil when free water, pumping or smearing is present, or when rutting exceeds 2 inches. Contractor shall wait until drying occurs and the re-scarify/de-compact the affected surface. • Minimize equipment passes / turning on stripped surface and on placed lifts. • Coordinate with Construction Manager on necessary stripping and excavation depths to prevent mixing soil zones. Perform zone control verification every 500 linear feet. • After backfill zone is replaced, de-compact / rip to a minimum depth of 12" prior to replacement of root zone material. • After root zone material is replaced, de-compact / scarify to a depth of 12" prior to placement of topsoil to avoid zone mixing.

Stationing, Soil Type, Management Unit	Requirements
280+00 – 294+50 MU-4 305+50 – 311+52 MU-6 (3 Zone) Enhanced	• Strip / stockpile topsoil. Depth 0-12". Use controlled stripping method (e.g., excavator peel) • Remove / stockpile root zone material. Depth 12-24". • Remove / stockpile backfill zone material. Depth below 24". • Contractor shall not strip, traffic, or place soil when free water, pumping or smearing is present, when rutting exceeds 1 inch, or when soil 'balls' adhere to tracks/tires. Contractor shall wait until drying occurs and the re-scarify/de-compact the affected surface. • Contractor to obtain approval from Construction Manager that conditions and equipment are acceptable for work. • Minimize equipment passes / turning on stripped surface and on placed lifts. • Coordinate with Construction Manager on necessary stripping and excavation depths to prevent mixing soil zones. Perform zone control verification every 250 linear feet. • After backfill zone is replaced, de-compact / rip to a minimum depth of 12" prior to replacement of root zone material. • After root zone material is replaced, de-compact / scarify to a depth of 12" prior to placement of topsoil to avoid zone mixing.

H. Existing Structures:

1. Contractor to replace structures that were removed from their original location in a condition equal to or better than original.

I. Waterways:

1. Keep ditches, culverts, and natural drainages continuously free of construction materials and debris.
2. Comply with the Colorado Department of Public Health and Environment, Larimer County, City of Thornton, and Army Corps of Engineers requirements.

J. Control of Water:

1. Construct, maintain, and operate cofferdams, channels, flume drains, sumps, pumps, or other temporary diversion and protection works. Furnish materials required, install, maintain, and operate necessary pumping and other equipment

for the environmentally safe removal and disposal of water from the various parts of the Work. Maintain foundations and parts of the Work free from water.

2. Reference Specification Section 31 23 19.

K. Wildlife Crossover Ramps

1. In accordance with Larimer County 1041 Permit Condition of Approval No. 62, Contractor shall install wildlife crossover ramps in trenches that are left unattended for more than 2 consecutive days. Install 4:1 sloped earthen wildlife crossover ramps (escape ramp) to the top or cordon off with construction fencing to prevent wildlife from becoming trapped. For excavations that exceed ¼ mile, install wildlife escape ramps at a minimum of one ramp per 1/4 mile of trench.

L. Cultural, Historical, or Archaeological Finds:

1. Reference Specification Section 01 41 10.

M. Endangered, Threatened, and Protected Species and Habitat:

1. Reference Specification Section 01 41 10.

N. Temporary Controls

1. Air Pollution Control:
 - a. Reference Subsection 1.03.B.8.
2. Noise Control:
 - a. Reference Subsection 1.03.B.9.

O. Erosion, Sediment, and Flood Control:

1. Maintain and promptly repair or replace facilities to control erosion and sediment releases, and to protect the Work and existing facilities from flooding during construction period.
2. Check Dams
 - a. Clean collected sediment material after every storm or as determined by biweekly inspections.

- b. Perform cleaning in a manner that will not result in sediment material washing downstream or into a storm sewer or drainage ditch.
 - c. Removed sediment shall be placed in an area selected by the Construction Manager where it can be cleaned of sticks and debris and allowed to dry.
 - d. Dispose of cleaned sediment onsite in an area designated by the Construction Manager. Dispose of sticks and debris offsite.
- 3. Temporary Diversion Channel and Drainage Ditches
 - a. Regrade diversion channels and drainage ditches as needed to maintain original grade and remove sediment buildup. If channels and ditches become difficult to maintain, install additional erosion control devices such as check dams or silt fences as directed by the Construction Manager.
- 4. Field Quality Control
 - a. Contractor shall conduct BMP inspections jointly with Construction Manager every 2 weeks. Replace or repair failed or overloaded silt fences, check dams, or other temporary erosion control devices within 24 hours after BMP inspections.

P. Quality Control

- 1. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix Conditions of Approval No. 39 included with the Project Manual.
- 2. Contractor shall allow Larimer County staff and consultants access to all work areas for inspections, construction observation, and quality assurance testing. Access shall be allowed throughout the project including pre-construction, during construction, and post-construction. Any Contractor communications with Larimer County shall be documented in writing and provided to Thornton's Construction Manager.

Q. Cleaning During Construction

- 1. At all times, Contractor shall clean and maintain areas covered by the Contract and adjacent properties and public rights-of-way and make sure these areas are

free from accumulations of waste, debris, and rubbish caused by construction operations.

2. Contractor shall conduct cleaning and disposal operations to comply with local ordinances and antipollution laws. Contractor shall not:
 - a. Burn or bury rubbish or waste materials on the Project site.
 - b. Dispose of volatile wastes, such as mineral spirits, oil, or paint thinner, in storm or sanitary drains.
 - c. Dispose of wastes into canals, wetlands, waterbodies, streams or waterways.
3. Contractor shall wet down dry materials and rubbish to prevent dust.
4. Contractor shall provide containers for collection and disposal of waste materials, debris, and rubbish.
5. Contractor shall cover or wet excavated material leaving and arriving at the site to prevent blowing dust and clean the roads and rights-of-way of any material falling from the haul trucks.
6. Provide approved containers for collection and disposal of waste materials, debris, and rubbish. At least weekly, dispose of such waste materials, debris, and rubbish offsite.
7. Waste which may attract rodents or other scavengers shall be removed daily.
8. Remove any accumulated waste and debris prior to final grading.
9. Prior to Project completion and immediately prior to final inspection, Contractor shall remove from the construction limits all temporary structures and materials, equipment, and appurtenances not required to remain as part of the Owner's Project.

3.03. POST CONSTRUCTION RESTORATION

- A. Any areas outside the Limits of Construction shown on the Contract Drawings shall be protected from damage by the Contractor. Any disturbance of vegetation or native ground outside the Limits of Construction shown on the Drawings shall be reclaimed by the Contractor at no additional expense to the Owner.

B. Disposal of Excess Backfill Zone Material

1. Excess excavation spoils (backfill zone material) shall be disposed of offsite by the Contractor.
2. It will be the full responsibility of the Contractor perform offsite disposal arrangements including disposal locations and volumes.

C. Restoration and Seeding Timing and Sequencing

1. Contractor shall coordinate with the Construction Manager so that post-construction restoration, including topsoil spreading, placement, preparation, and seeding takes place after the Owner's fiber optic cable installation contractor has mobilized, installed the fiber optic cables, and demobilized.

D. Topsoil Spreading, Placement, and Preparation

1. Owner will perform soil testing on stockpiled topsoil in non-agricultural areas to determine if soil amendments and/or fertilizers need to be incorporated before Contractor performs final seeding / restoration. Contractor to provide Construction Manager with a minimum of 45 calendar days of advanced notice of when topsoil is scheduled to be replaced.
2. Owner will perform post-construction soil testing on replaced root zone material and topsoil in agricultural areas, after final grading is complete, to determine if soil amendments and/or fertilizers need to be incorporated before Contractor demobilizes restoration equipment. Contractor to provide Construction Manager with a minimum of 45 calendar days of advanced notice of when topsoil is scheduled to be replaced.
3. Contractor shall uniformly distribute and smoothly grade soil over the entire disturbed areas in preparation for seeding. Soil shall be placed in a manner to match pre-construction contours and to avoid concentrated flow paths.
4. Topsoil spreading and placement shall take place within 21 calendar days following completion of major pipeline construction through a given property or parcel. Locations immediately around appurtenant structures can be left open / unrestored as required for completing structures, pipeline filling, draining, testing, or installation of pipeline closure pieces.

5. Should final seeding or restoration not take place within 14 days of topsoil placement, Contractor shall stabilize the surface. Reference 3.02.F.
6. In preparation for seeding or final restoration, Contractor shall scarify or rip topsoil to a depth of 6 inches. Wetland areas shall be prepared using a chisel plow to mechanical rip the subsoil prior to topsoil replacement.
7. Topsoil scarifying or ripping shall take place in two perpendicular directions.
8. Fertilizers or amendments (if needed) shall be applied evenly to the soil surface and thoroughly worked into the top 6-inches of the surface at Owner recommended rates. Prior to delivering amendments to the site, Contractor shall coordinate closely, and in a timely manner, with the Construction Manager and the Owner's soil scientist to evaluate the boron content of any imported amendments. Any amendments that would raise the boron content 0.5 ppm above existing conditions will not be allowed or will have to be applied at reduced rates.

E. Seeding

1. Seedbed Preparation: The seedbed shall be free of weeds, plant matter, rocks, clods, and other impervious material over two (2) inches in diameter. Seedbed shall be smooth and free of large clumps, fluffy yet firm, moist but not wet.
2. Seeding
 - a. Contractor shall place seed between November 15 and April 30 on unfrozen ground unless favorable conditions exist outside this window and desired seeding time frame is approved by the Construction Manager. Contractor may need implement a compressed construction schedule for work involving wetland impacts to account for timing associated with stockpile storage and seeding.
 - b. Seeding shall be initiated within 48 hours of soil preparation to discourage weed competition. Seed shall be evenly distributed over the ground on a day without windy conditions and shall be distributed into a slightly moist seedbed.
 - c. Drill Seeding

- (1) Contractor shall use an approved low impact drill seeder with Coulter wheels, adjustable depth bands, and a maximum drill row spacing of 4 inches.
- (2) Drill seeding shall result in ½ inch seed placement.
- (3) Seed shall be drilled in two perpendicular directions.

d. Hand Broad Cast Seeding

- (1) Hand-broadcasting methods will be allowed in areas that are too steep (greater than 4:1 slope) or too isolated to operate a drill seeder.
- (2) Broadcast seeding areas must be approved by the Construction Manager.
- (3) Areas allowed for broadcast seeding will require double the seeding rate and shall be 'raked in' or otherwise covered with soil to a depth of 1/2 inch.

- e. All seeded areas with the exception of wetland areas shall be mulched, applied with tackifier in accordance with 3.02.F. Within 12 hours after mulching, seeded areas shall be lightly watered. Contractor shall water seeded areas frequently for 6 weeks to keep soil moist unless weather conditions provide favorable moisture and temperatures.

3. Weed Control:

- a. Control transfer or introduction of noxious weeds into the project site until Final Completion of the project.
- b. For perennial weed control, use spot chemical spraying or hand weeding after grass plants are up and fairly mature, at the minimum, past the three (3) to five (5) leaf stage.
- c. The use of Journey selective, pre-emergent herbicide or approved equal shall be required in areas infested with Cheatgrass (*Bromus tectorum*) and other grassy weeds. Journey shall be applied in late summer prior to germination of Cheatgrass and other winter annual weeds.

4. Planting

- a. Prepare the ground for planting in accordance with the type of tree or shrub being planted.
- b. Contractor shall water trees and shrubs immediately after planting and every two weeks until plantings have been stabilized and established.
- c. Contractor has the option of using slow watering blankets ("tree diapers").
- d. Contractor to coordinate with Construction Manager to have planting locations staked and identified. Contractor shall provide Construction Manager with a minimum of 45 calendar days advanced notice of scheduled staking.

F. Final Stabilization Establishment and Acceptance:

1. Seeded areas will not be accepted until the stand of grass displays uniform coverage of the seed mix planted, with all species of the mix being well represented, and minimal weeds are present, as determined by the Owner.
2. Final stabilization is when all restoration is complete and seeding has reached at least 70% uniform vegetative cover as determined by the Construction Manager and applicable stormwater permits have been closed out.
3. 70% shrub plantings have demonstrated survival.
4. Less than 10% weed coverage in revegetated areas.

G. Gravel Driveway and Road Replacement and Restoration

1. Includes private gravel driveways, roads, and the crossing of Larimer County Road No. 11 and No. 54.
2. Contractor shall replace and restore gravel driveways and roads that are crossed and disturbed in accordance with Larimer County standards and requirements including, but not limited to, water, providing aggregate base, grading, and establishing a 5% crown. The replacement and restoration of Larimer County Road No. 54 shall also include scarifying, initial magnesium chloride application, compaction, and final magnesium application. Contractor shall reference the

Contract Drawings for further information on crossings of Larimer County Roads No. 11 and No. 54.

3. In addition to the Contract Documents and Larimer County standards and requirements, the replacement and restoration shall be in accordance with the Larimer County approved Initial and Final County Roads Inventory and Road Maintenance and Repair Plan.

H. Gravel Road Replacement and Restoration – LCR No. 56

1. Includes Larimer County Road No. 56 where work involves the installation of the 42-inch pipeline, fiber optic conduits and handholds, and the potential relocation of ELCO's 2-inch waterline.
2. Contractor shall replace and restore Larimer County Road No. 56 accordance with Larimer County standards and requirements including, but not limited to, water, providing aggregate base, grading, establishing a 5% crown, scarifying, initial magnesium chloride application, compaction, and final magnesium application magnesium application. Contractor shall reference the Contract Drawings for further information on work within Larimer County No. 56.
3. In addition to the Contract Documents and county standards and requirements, the replacement and restoration of Larimer County Road No. 56 shall be in accordance with the Larimer County approved Initial and Final County Roads Inventory and Road Maintenance and Repair Plan.

I. Access Restoration

1. Upon completion of construction, remove vehicle tracking control pads and restore ground surface disturbed by access road construction to original grade. Replace damaged or broken culverts with new culvert pipe of same diameter and material. Replace any surfacing that existed prior to mobilization. At Permanent (P) Access Locations, place aggregate gravel base to the dimensions and thickness shown on the Contract Drawings. For Temporary (T) Access Locations, restore to pre-construction conditions.

J. Removal of Temporary Installations.

1. Do not remove BMPs without formal written restoration acceptance from the Construction Manager.

2. BMP materials shall remain the property of the Contractor and shall be removed from the site when directed by the Construction Manager.
 3. Remove silt fence after upslope area has been permanently stabilized.
 4. Remove clearing limit, tree, and sensitive area protection fence after permanent stabilization is complete and accepted by the Construction Manager.
 5. Dress sediment deposits remaining after fence has been removed to conform to existing grade. Prepare and seed graded area.
- K. Contractor to submit post-construction survey of final topography, drainage culverts, irrigation ditches, and access driveways to confirm that restoration was returned to pre-construction lines and grades. The post-construction survey shall be submitted prior to final completion.
- L. Final Cleaning
1. Remove any final wastes and debris prior to final grading.
 2. At the completion of Work and immediately prior to final inspection, remove from the sites of the Work all temporary structures and materials, equipment, and appurtenances not required as a part of or appurtenant to the completed Work or to remain the property of the Owner.
 3. Contractor to refer to Larimer County 1041 Permit Compliance and Contractor Requirements Matrix Conditions of Approval No. 67 included with the Project Manual.

END OF SECTION

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SECTION 33 05 07

CARRIER PIPE INSTALLATION AND BACKFILL

PART 1 - GENERAL

1.01. DESCRIPTION:

- A. This section includes the requirements for installing the Carrier Pipe in the tunnel's Casing Pipe and backfill of the annulus with cellular concrete.
- B. This is a performance specification. Minimum requirements are presented herein. It is the Contractor's responsibility to develop and implement the design to fulfill the specified requirements.
- C. The Contractor shall give the Engineer a minimum of seven days notice of the start of work.
- D. Perform all work in the presence of the Owner's representative, unless the representative has granted prior approval in writing to perform such work in his/her absence.

1.02. REFERENCES:

- A. Geotechnical Reports
 - 1. Report dated April 17, 2026, prepared by Brierley Associates entitled "Geotechnical Baseline Report, Thornton Water Project – Segment F.1"
 - 2. Report dated July 15, 2026, prepared by CMT entitled "Geotechnical Data Report, Thornton Water Project – Segment F.1"
- B. Applicable Standards:
 - 1. All work shall be performed in accordance with applicable regulations of all federal, state and local regulations, codes and standards.
 - 2. ASTM C 495 - Standard Test Method for Compressive Strength of Lightweight Insulating Concrete
 - 3. ASTM C 796 - Standard Test Method for Foaming Agents for Use in Producing Cellular Concrete Using Preformed Foam

4. ASTM C 869 - Standard Specification for Foaming Agents Used in Making Preformed Foam for Cellular Concrete.
5. Occupational Safety and Health Administration (OSHA):
 - a. 29 CFR Part 1926 - Safety and Health Regulations for Construction.

1.03. DEFINITIONS:

- A. Carrier Pipe: Refers to the 42-inch welded steel water line and fiber optic duct lines.
- B. Backfill: Filling of the annular space between the Carrier Pipe and Casing Pipe.
- C. Bulkhead: Material placed between the Carrier Pipe and the Casing Pipe. Bulkheads are typically required at both ends of the Casing Pipe to contain Cellular Concrete in the annular space between the Carrier Pipe and Casing Pipe.
- D. Casing Spacers: Prefabricated units that provide necessary separation between Carrier Pipes and the Casing Pipe while not impeding the flow of backfill grout.
- E. Cellular Concrete: A low density, lightweight, cementitious material that contains stable air or gas cells as preformed foam uniformly distributed throughout the mixture, designed to fill the annular space between the Carrier Pipes and Casing Pipe.

1.04. QUALIFICATIONS:

- A. The Contractor shall be experienced in the installation and backfilling of pipe with Cellular Concrete in tunnels using methods, materials, and equipment suitable to this project. Specifically, the Contractor shall have successfully completed at least five projects installing Carrier Pipe in tunnels. The Contractor may use one person as the Supervisor for all installation and backfill activities or two different persons; one for pipe installation and one for backfilling.
- B. Project Control must be set by a surveyor licensed by the State of Colorado and have at least five years related experience in surveying.
- C. The Superintendent shall be thoroughly knowledgeable about the transportation, placement, and securement of prefabricated pipe in tunnels. The Superintendent shall have experience installing two similar projects using the equipment proposed by the Contractor for this project.

- D. The Foreman shall be thoroughly knowledgeable about the properties, behavior, and placement methods of cellular concrete in underground applications. The Foreman shall have successfully completed at least two similar projects in which the pipe annulus in a tunnel was backfilled with Cellular Concrete.
- E. The Contractor's Safety Supervisor shall have at least five years' experience in safety management.

1.05. SUBMITTALS:

- A. Submit in accordance with Section 01 33 00.
- B. At least 90 days prior to the start of work, all submittals, including drawings and calculations, shall be required for the sole purpose of providing the Engineer enough details to confirm that the Contractor's planned work and work in progress is in accordance with the Contract Documents. The Engineer's review shall not be construed to relieve the Contractor in any way of responsibilities under the Contract Documents. Do not begin work on any item requiring a submittal until the required relevant submittals have been reviewed and approved by the Engineer. All structural designs and other engineered components shall be signed and sealed by a Professional Engineer licensed in the State of Colorado.
- C. Submit the following qualifications:
 - 1. The name and qualifications of the Contractor(s) that shall perform the work with descriptions of reference projects including Owner's name and contact information and project field superintendent. The name and qualifications of the surveyor who shall perform the work.
 - 2. The name and qualifications of the Superintendent..
 - 3. The name and qualifications of the Foreman.
- D. Submit a health and safety plan/accident prevention program, including a code of safe practices and an emergency plan.
- E. Submit a Carrier Pipe installation Work Plan including, as a minimum:
 - 1. Details of the Carrier Pipe transportation, line and grade surveying, line and grade control, mating, and joint finishing and sealing.

2. A schedule for the work identifying all major construction activities as independent items. Include working hours for each activity, and a written description of construction methods and equipment, to be employed in completing work activities shown on the schedule. Review schedule with the Engineer and update and resubmit as required by these Specifications.
 3. Spatial layout of the Carrier Pipes within the Casing Pipe, including all blocking and bracing or casing spacers.
 4. Methods, procedures, and equipment for setting, monitoring, controlling, and adjusting the alignment and grade of the Carrier Pipe both during and after installation in the Casing Pipe but prior to backfilling.
- F. Submit a backfilling Work Plan including:
1. Mix design.
 2. Description of equipment and methods proposed to mix cellular concrete, including mixing equipment, quantity controls, and instrumentation. Provide results from another project using the same mix design and same equipment as proposed. At a minimum, the mixture shall have been tested for unit weight (wet density), viscosity, air content at the time of cylinder casting, and results of compression testing. Provide evidence that the cellular concrete was placed properly in the previous project.
 3. A schedule for the work identifying all major construction activities as independent items. Include working hours for each activity, and a written description of construction methods and equipment, to be employed in completing work activities shown on the schedule. Review schedule with the Engineer and update and resubmit as required by these Specifications.
 4. Injection methods for cellular concrete backfill including ports or grout tubes, pumping equipment, hoses, boosters, pumping distances, flow rates, and pressures. Include details for securing the injection pipes, backfill sequence and stages both in length and in elevation, and injection locations. Include methods and description of instrumentation to monitor and control placement of the cellular concrete, and procedures to be used to verify complete placement and check for voids.
 5. Details for backfilling in the presence of water.

6. Calculations shall be submitted which evaluate:
 - a. Theoretical annulus volume for actual Casing Pipe ID and Carrier Pipe OD with adjustments for bells and spacers.
 - b. Buoyant forces generated during backfilling of each stage.
 - c. Bending stresses on the pipe between tiedowns and braces while ballasted and before backfill.
 - d. Maximum allowable backfill injection pressure.
- G. Submit the following during construction within the specified time restrictions:
 1. Written Daily Logs – Daily Logs shall be submitted to the Engineer within one week after performing each item, or before the next construction step, whichever is less, unless specified otherwise. Daily logs shall include, as a minimum, stations and length for Carrier Pipe installed; stations lengths and volumes of cellular concrete placed; the annulus volume versus the actual volume of cellular concrete placed for each pour; plus, the pressures, flow meter, and unusual conditions relative to cellular concrete placement.
 2. Survey Results – Results of surveys of the Casing Pipe and Carrier Pipe shall be submitted to the Engineer within one week after performing each item, or before the next construction step, whichever is less, unless specified otherwise. One survey shall be made of the Casing Pipe before Carrier Pipe installation, one shall be made for the Carrier Pipeline and grade after installation but prior to backfilling, and one survey of the Carrier Pipe shall be made after backfilling.
 3. Results of field and laboratory testing shall be submitted within three days of the test completion.

PART 2 - PRODUCTS

2.01. MATERIALS:

- A. The Carrier Pipes shall be as shown on the Contract Drawings and as specified in the Contract Documents.
- B. Cellular Concrete:

1. Annulus backfill shall be Cellular Concrete.
 2. Cellular Concrete shall be composed of cement, water and foam. No aggregate or fillers are allowed.
 3. Laboratory tests conducted as part of the mix design process must use the same materials as shall be used for the production Cellular Concrete.
 4. The foaming agent for Cellular Concrete shall be in accordance with ASTM C 869 and shall be tested in accordance with ASTM C 796.
 5. Cellular Concrete shall be a non-shrink mix.
 6. Cellular Concrete shall have a minimum pH of 11.5 after curing.
 7. Cellular Concrete shall have a minimum wet density of 35 pcf unless in the presence of water where a minimum wet density of at least 65 pcf is required.
 8. Cellular Concrete shall have a minimum 28-day compressive strength of 250 psi and shall be tested in accordance with ASTM C 495.
- C. Bulkheads: Bulkheads at the ends of the pipe shall prevent spillout of the Cellular Concrete and not damage or degrade the Casing Pipe or Carrier Pipes during installation. Materials used to seal the annular spaces shall be free of materials that shall corrode or damage the Carrier Pipes in any way.
- D. Casing Spacers:
1. Casing Spacers shall be supplied by a company specializing in the manufacturing of casing spacers and specifically designed for placing pipe in tunnels and as skids for the pipe to ride on during installation.
 2. Casing Spacers shall be non-conducting material that is rigid under the imposed loads and does not damage the Casing Pipe.
 3. The spacers shall cathodically isolate the Carrier Pipe from the Casing Pipe with a resistive material.
 4. The spacers shall be variable in size or adjustable to place the position of the Carrier Pipe considering variations of the Casing Pipe.

5. Spacers shall be sized to allow no greater than a one-inch gap between the edge of spacers and the inside of the Casing Pipe at any point.
6. Spacers shall be designed to provide necessary clearances between the Casing Pipe and the Carrier Pipes, and between Carrier Pipes, to accommodate backfill grout pipe(s) and operations. Minimum clearances are provided herein.
7. Casing spacers shall be by CCI Piping Systems, Raci Spacers, Advanced Products and Systems, or approved equal.

PART 3 - EXECUTION

3.01. GENERAL:

- A. The Carrier Pipes shall have internal bracing as necessary to protect the pipe and control deflections including out-of-round distortions during handling, installation, annulus backfilling and service life.
- B. The Carrier Pipes shall be ballasted or firmly anchored or blocked in-place to prevent flotation and movement during annulus backfilling.
- C. Pipe installation and backfilling shall be conducted under the direct supervision of the Superintendent.

3.02. PREPARATION:

- A. Carrier Pipe installation shall not commence until the tunnel is prepared for pipe installation in accordance with the following requirements:
 1. The tunnel excavation has been stabilized.
 2. Contact grouting is complete.
 3. The line and grade of the Casing Pipe has been surveyed and has been verified to allow for installation of the Carrier Pipes to the specified tolerances and clearances.
 4. The Casing Pipe has been cleaned as specified herein.

3.03. SURVEYS:

- A. Be performed by a Professional Land Surveyor licensed in the State of Colorado.

- B. Surveys shall be at intervals not exceeding 20 ft and shall be for both line and grade to an accuracy of 0.01 ft or better.
- C. Conduct the following surveys:
 - 1. Completed Casing Pipe at an identifiable location in the Casing Pipe cross section prior to installation of the Carrier Pipes.
 - 2. Carrier Pipe invert prior to annulus backfilling.
 - 3. Carrier Pipe invert following annulus backfilling.

3.04. MAINTENANCE:

- A. Keep the site clean and orderly. Site improvements shall be protected from damage or becoming soiled through suitable temporary covering.
- B. Upon completion of the Work, remove waste from the site and the site restored to as near its original condition as possible. Remnants of drilling fluid or grout that may have splattered on improvements shall be completely removed.
- C. Maintain and repair Work as required.
- D. Where measurements and observations indicate possibility of failure or excessive movement of Carrier Pipe, take appropriate action immediately and provide a plan and calculations for immediate repair and reinforcing of the Work that is prepared, stamped, and signed by a Professional Engineer registered in the State of Colorado.

3.05. TOLERANCES AND CLEARANCES:

- A. The Carrier Pipe shall be installed to the line and grade shown on the Contract Drawings.
- B. At all locations, the invert of the Carrier Pipe shall be within 1 in. of the elevation shown on the Contract Drawings. No reverse grades are allowed.
- C. At all locations, the Carrier Pipe shall be within 6 in. of the horizontal alignment shown on the Contract Drawings.
- D. Changes in Carrier Pipe alignment and grade shall be made gradually such that pipe joints are mated within the pipe manufacturer's specifications.

- E. The Carrier Pipe shall have a minimum clearance of four inches between the outside of the pipe and the closest point of the casing pipe in all directions.
- F. If the Carrier Pipe is off line and/or grade by more than the specified tolerances, the Contractor or Subcontractor shall adjust, repairs and changes as necessary to achieve the specified tolerances.
- G. If the Carrier Pipe is off line and/or grade by an amount that requires, in the opinion of the Engineer, re-design of any structure, the Contractor shall be responsible for all redesign costs.

3.06. INSTALLATION METHODS:

- A. The Contractor shall install the Carrier Pipes into the casing pipe by sliding an assembled pipe into the tunnel. Complete each joint outside the tunnel prior to pushing or pulling into the tunnel. Complete all exterior pipe treatments on the pipe prior to installation into the tunnel.
 - 1. Use Casing Spacers attached to the Carrier Pipes as skids. Adjust the position of the Carrier Pipes within the spacers as necessary to achieve proper line and grade when the pipe is at the final position. Distance between spacers shall be determined by the spacer manufacturer. At a minimum, spacers shall be located at 5-ft intervals.
- B. Ensure that each pipe segment is firmly secured to prevent flotation, settlement, lateral and axial movement, and pipe deflection during the design life of the Carrier Pipe.
- C. Pipe joints shall be installed in accordance with the pipe manufacturer's specifications and the Contract Documents.

3.07. SEALING AND BACKFILLING METHODS:

- A. Before placement of cellular concrete in the tunnel, demonstrate the capability to produce cellular concrete that meets the specified density and strength requirements. This shall be verified using trial mixes identical to those proposed for the project and utilizing the same equipment intended for placement. Confirm the ability to pump the Cellular Concrete mix the distances proposed without compromising the quality of the Cellular Concrete. This requirement may be satisfied by providing records from

previous projects in which the same mix, water and cement sources, materials and equipment were successfully used.

- B. Prior to backfilling, ensure the annulus is cleaned of debris, soil, water, and other materials that may be deleterious to the Casing and Carrier Pipes.
- C. Completely backfill the annulus between the Carrier Pipe and the Casing Pipe with Cellular Concrete. Placement methods shall completely fill the spaces below the Carrier Pipe and around the Carrier Pipe support system components.
- D. The method of backfilling shall ensure that the annulus is filled between injection points and from the tunnel invert to the tunnel crown.
- E. Place Cellular Concrete backfill in multiple lifts to prevent pipe flotation unless ballast, stiffeners or pipe supports, and closely spaced blocking of sufficient structural rigidity are provided to prevent pipe flotation, movement, or damage to the pipe. Lift thickness required to prevent flotation and damage to the pipe shall be determined by the Contractor.
- F. Cellular Concrete shall not be subject to free fall greater than 10 ft. Piston or plunger pumps shall not be used for pumping of Cellular Concrete. The pressure of the Cellular Concrete against the Carrier Pipe shall be determined by the Contractor and based on recommendations from the Carrier Pipe manufacturer.
- G. The injection points for Cellular Concrete shall be at intervals not greater than every 250 ft. Closer spacing of discharge points shall be used as necessary to assure continuity between discharge points.
- H. Cellular Concrete shall be injected from the top of the shafts or pumped from the base of the shaft. Vertical drop holes shall not be allowed.
- I. Maintain a supply of water in the tunnel at the location of the Cellular Concrete backfilling operations or the Bulkhead as appropriate to facilitate flushing of injection lines or outlets.

3.08. QUALITY CONTROL:

- A. Monitor and record as a minimum all data necessary to complete the required Submittals.
- B. Testing:

1. Testing services performed by the Contractor.
2. Test methods shall be in accordance with ASTM C 495. Cast the specimens into cylinders at least 2 in. in diameter and 4 in. tall. Separate and remove the specimens for testing by cutting and trimming the forming material surrounding the cylinders.
3. Cellular Concrete Mix Design: One set of compression test specimens shall be made. One set of specimens shall be tested at an age of 28 days. The mix shall be tested for unit weight and viscosity at the time of cylinder casting.
4. Index Testing of Cellular Concrete: A set of index tests shall be made from the first batch of Cellular Concrete mixed each day, after a change in mix design, and from each batch of Cellular Concrete from which compression test specimens are made. Additionally, index tests shall be conducted every two hours to verify the Cellular Concrete's properties. Index tests shall include as a minimum: the wet unit weight (wet density) and viscosity at the time of placement.

3.09. CONSTRUCTION RECORDS:

- A. The Contractor shall maintain Daily Shift Reports for pipe installation and backfilling. The Shift Reports shall be signed by the site superintendent or shift foreman and shall contain the following:
 1. Crews and subcontractors onsite with their personnel and equipment, and the work performed. The reports shall be broken down into work time and down/standby time for each crew and subcontractor.
 2. Record of pipe installed.
 3. Grout Testing Reports.
 4. Record of backfilling/annular sealing materials, and configuration of the seals. Record of backfill quantity and maximum delivery pressure in each.
 5. Problems or unusual conditions encountered, and actions taken to address these situations.

3.10. CLEAN UP AND RESTORATION:

- A. Perform restoration as the work progresses and when completed. Do not delay restoration work, and complete restoration no later than 30 days after the Carrier Pipes are in place. Any testing or further inspection necessary for final completion and inspection of the Carrier Pipes are not cause for any delay of restoration work required under this Contract. Include all property that was affected by the construction operations. Such final restoration that cannot be performed within the 30-day period due to adverse weather conditions may, upon written request and including a proposed procedure and time schedule, be performed as approved by the Engineer. Any delayed restoration shall be contingent upon providing suitable safe temporary facilities without inconvenience or nuisance.

END OF SECTION

SECTION 33 05 26

UTILITY IDENTIFICATION

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section describes materials and installation of pipeline markers, warning tape, and tracer wire.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's catalog literature and product data sheets describing the materials, colors, letter size, and tape width and thickness.

PART 2 - MATERIALS

2.01. PIPELINE MARKERS

- A. The Contractor shall provide sign posts and all other items required for sign installation as shown on the Construction Drawings.

2.02. UNGROUND WARNING TAPE

- A. Manufacturer: One of the following or equal:
 - 1. Seton Name Plate Co.
 - 2. T. Christy Enterprises, Inc.
- B. Material:
 - 1. Polyethylene tape for prolonged underground use.
 - 2. Minimum tape thickness: 4 mils.
 - 3. Overall tape width: 6 inches.

4. Message: "CAUTION" with the name of the service followed by "LINE BURIED BELOW." in black lettering on colored background in accordance with approved APWA colors (see table below).
5. Aluminum backing or solid aluminum core.

Service	Color
Cable, Tele, Fiber Optic	Orange
Gas	Yellow
Electric	Red
Telephone	Orange

Service	Color
Water	Blue
Sewer	Green
Chemical	Yellow
Reclaimed Water	Purple

2.03. TRACER WIRE

A. Manufacturers: One of the following or equal:

1. Kris-Tech Wire.
2. Corpro.

B. Materials:

1. Solid copper conductor
2. Thickness minimum: 12 gauge.
3. Insulation:
 - a. Match insulation color to the color of the pipe being installed.
 - (1) Raw Water: Blue.
 - (2) Fiber Optic: Orange.
 - b. UF type, direct bury.
 - c. 30 mil HMWPE.

C. Splicing Kit:

1. Manufacturers: One of the following or equal:
 - a. Rexel, 3M-82 A1N.

D. Station Box:

1. Lid and collar materials: Cast iron.
2. Able to withstand heavy traffic loading.
3. Manufacturers: One of the following or equal:
 - a. Farwest Corrosion Control Co, Glenn 4 Test Station.

2.04. TRACER WIRE TEST STATIONS

- A. Tracer wire test leads for the 42" steel pipeline shall be incorporated into the cathodic protection test stations. Refer to Section 26 42 13 for cathodic protection test station requirements.
- B. Fiber optic tracer wire test stations shall be Copperhead Industries, SnakePit, Model CD14*2T-SW two-way switchable.
 1. Match color of conduit being monitored: Fiber Optic: Orange.
- C. Fiber optic tracer wire test stations shall be installed inside fiber optic handholes/vaults.

2.05. LOCATOR BALLS

- A. Manufacturers:
 1. 3MTM - Electric Marker System (EMS) 1403 Water SR, Blue, no equal.
- B. Materials:
 1. Water-resistant polyethylene marker ball containing a passive antenna operable without any external power source. Marker balls shall be self-leveling resulting in accurate horizontal positions regardless of ground placement. Marker balls shall be compatible with a 3M Dynatel Locator.
 2. Diameter: 4-inch.
 3. Color: Blue.
 4. Passive detection range: 0 to 5 feet.

PART 3 - EXECUTION

3.01. PIPELINE MARKER INSTALLATION

- A. The Contractor shall install pipeline markers as shown on the Construction Drawings.

3.02. WARNING TAPE INSTALLATION

- A. During backfilling of each underground piping system, continuously install plastic warning tape directly over the buried line(s) as shown on the Construction Drawings.
- B. Where multiple small lines are buried in common trenches and do not exceed an overall width of 16-inches, install a single strip of identification tape.

3.03. TRACER WIRE, TEST STATIONS, AND TESTING

- A. Wire Installation:
 - 1. Tracer wire shall be installed as shown on the Construction Drawings.
 - 2. Tracer wire installation shall utilize sufficient spool lengths of wire and be continuous between test stations. Wire splices are not permitted, except where connecting to an existing tracer wire system.
- B. Test Station Installation
 - 1. Install test stations where indicated on the Drawings.
- C. Testing
 - 1. The Contractor is response for all tracer wire continuity testing including providing equipment, qualified personnel, and record keeping.
 - 2. All new tracer wire installations shall be located and verified by the Contractor using typical low frequency (512 Hz) line tracing equipment.
 - 3. Testing must be conducted after rough grading and again before final acceptance, and witnessed by the Construction Manager, as applicable. Notify the Construction Manager a minimum of 48 hours in advance of testing.

3.04. LOCATOR BALL INSTALLATION

- A. Install locator ball where indicated on the Drawings.

END OF SECTION

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SECTION 33 11 00

GENERAL PIPING COMPONENTS AND REQUIREMENTS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section describes the requirements for flange gaskets, flange assembly studs, nuts, and washers for piping, fittings, and valves.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit certified copies of mill test reports for studs, nuts, and washers including specified coatings. Provide recertification by an independent domestic testing laboratory for materials originating outside of the United States.
- C. Submit manufacturer's catalog literature and product data sheets for flange gaskets showing dimensions and bolting torque recommendations.
- D. Submit affidavits of compliance with referenced standards.

PART 2 - MATERIALS

2.01. FLANGE ACCESSORIES

- A. Bolts (Studs), Nuts, and Washers
 - 1. Bolts shall not be used. Use studs (all thread) in lieu of bolts.
 - 2. Studs shall conform to ASTM A193, Grade B7, with nuts conforming to ASTM A194, Grade 2H (heavy hex nuts).
 - 3. Provide washers for each nut in accordance with ASTM F436. Washers shall be of the same material as the nuts.
 - 4. Threads shall be formed by means of rolling, not cutting or grinding.
 - 5. Lubricant for stainless steel bolts and nuts shall be chloride-free and shall be Huskey Lube-O-Seal, or equal.
- B. Gaskets

1. Flange gasket materials and type shall be in accordance with AWWA C207, Table 1. The minimum gasket thickness shall be 1/8". See Drawings for pressures and flange classes.
 2. Manufacturers:
 - a. Durlon, Garlock, or Klingersil.
- C. Flange Insulating Kits
1. Refer to Section 26 42 13.
- D. Lubricant for Slip-On Joint Gaskets
1. Where required a non-toxic vegetable soap lubricant shall be supplied with the pipe or fittings in sufficient quantities for installing the pipe.
 2. Gaskets and lubricant shall be provided by the manufacturer of the pipe on which they are to be used.
- 2.02. BLIND FLANGES
- A. Refer to Section 33 11 11.

PART 3 - EXECUTION

3.01. FLANGED PIPE ASSEMBLY

- A. Assemble flanged pipe without forcing or stressing the pipe, adjacent connecting valves, or other equipment.
- B. Before bolting up, clean flanges by wire brushing and align the flange faces to the design plane to within 1/16-inch and align the flange bolt holes to within 1/8-inch maximum offset.
- C. Examine studs, nuts, and washers for defects such as burrs, cracks, and rust. Inspect each flange gasket to verify that it is the correct size, material, and type for the specified service and that it is clean and undamaged. Replace as needed.
- D. Coat threaded portions of studs and nuts with lubricant, place gasket between flange faces aligning the gasket and flange bolt holes, insert studs, and tighten nuts. Do not use more than one gasket between flange faces. Tighten the nuts to the manufacturer's specifications, using the recommended cross-bolting pattern in multiple steps of increasing torque, until the final torque requirements are achieved. Do not over torque.

- E. Stud lengths shall extend completely through their nuts. Studs that extend through their nuts by one or more threads will be considered completely engaged. Assembled studs and nuts not meeting this requirement will be rejected.

3.02. PAINTINGS AND COATINGS

- A. Coat buried flange assemblies (except for studs and nuts) per Section 09 90 00, System No. 21. Coat buried flange studs, nuts, and washers per Section 09 90 00, System No. 24, then wrap the buried flange joint with polyethylene wrap per Section 09 97 06.
- B. Coat entire flange assemblies in exposed service, including studs and nuts, per Section 09 90 00, System No. 10.

3.03. TESTING

- A. If flanges leak under pressure testing, loosen or remove the studs and nuts, reset or replace the gasket, reinstall or retighten the studs and nuts, and retest the joints. Joints shall be watertight.

END OF SECTION

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SECTION 33 11 04

MODULAR MECHANICAL SEALING DEVICES

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section includes materials and installation for modular mechanical sealing devices.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. List materials of construction with ASTM material reference and grade.
- C. Submit manufacturer's instructions for installing modular mechanical sealing devices.

PART 2 - MATERIALS

2.01. MODULAR MECHANICAL SEALING DEVICES

- A. Modular mechanical sealing devices shall utilize interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe sleeve and the passing pipe. Assembled links shall form a continuous rubber belt around the pipe with a pressure plate under each bolt head and nut.
- B. Materials of construction shall be as follows:

Compound	Material
Pressure Plate	Carbon Steel, Type 304 or 316 Stainless Steel, or Delrin Plastic
Bolts and Nuts for Links	Type 316 Stainless Steel
Sealing Element	EPDM Rubber

- C. The size of the wall sleeve needed to accommodate the passing pipe shall be as recommended by the modular mechanical sealing device manufacturer.

- D. Provide centering blocks in 25% of the sealing elements on pipelines larger than twelve 12-inches in diameter.
- E. The modular mechanical sealing devices shall be Pipeline Seal and Insulator, Inc. Link-Seal®, Advance Products & Systems, Inc. INNERLYNX®, or approved equal.

2.02. PIPE PENETRATIONS, FILLER AND SEALANT

A. Polyethylene Foam Filler

1. Foam filler shall be an extruded, closed-cell polyethylene foam rod ½-inch larger in diameter than the annular space.
2. Polyethylene foam filler shall be W.R. Meadows KOOL-ROD™, Dow Chemical Company® Ethafoam™, or approved equal.

B. Polyethylene Sealant

1. Sealant shall be a multipart, polyurethane sealant, for continuous immersion in water. The sealant shall cure at ambient temperature.
2. Polyurethane sealant shall be Sika Corporation Sikaflex®-2C NS, or approved equal.

2.03. EPOXY BONDING MATERIAL

- A. Epoxy bond material shall be Keysite 740, Keysite 742, or approved equal.

2.04. SILICON SEALANT

- A. Silicon sealant shall be Dow-Corning® 790, General Electric Silpruf® SCS2000, or approved equal.

PART 3 - EXECUTION

3.01. TESTING

- A. Pressure test wall sleeves and collar assemblies at the place of fabrication to demonstrate watertight integrity of the seal between the collar and the sleeve. The test shall be at a pressure of 20 psi for four hours' duration and shall show zero leakage.

3.02. INSTALLATION

- A. Provide modular mechanical sealing devices where shown in the Construction Drawings. Orient tightening bolts to the interior or the vault or manhole. Install in accordance with the manufacturer's instructions.
- B. Provide one modular mechanical seal when the wall is eight-inches thick, or less. Provide two modular mechanical seals when the wall thickness is greater than eight-inches thick.
- C. Pack the annular space with polyethylene foam filler and fill the ends of the penetration with two-inches of elastomeric sealant on both sides of the structure.

END OF SECTION

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SECTION 33 11 11

WELDED STEEL TRANSMISSION PIPE

PART 1 - GENERAL

1.01. REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
 - a. B16.9, Factory-Made Wrought Buttwelding Fittings.
 - b. B36.10M, Welded and Seamless Wrought Steel Pipe.
 - c. BPVC SEC VIII, Div. 1, Rules for Construction of Pressure Vessels.
 - d. BPVC SEC IX, Welding and Brazing Qualifications.
2. American Society for Nondestructive Testing Inc. (ASNT):
 - a. SNT-TC-1A, Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing.
3. American Water Works Association (AWWA):
 - a. C200, Steel Water Pipe - 6 In. (150 mm) and Larger.
 - b. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. (100 mm) and Larger - Shop Applied.
 - c. C206, Field Welding of Steel Water Pipe.
 - d. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
 - e. C208, Dimensions for Fabricated Steel Water Pipe Fittings.
 - f. C602, Cement-Mortar Lining of Water Pipelines in Place - 4 In. (100 mm) and Larger.
 - g. M11, Steel Pipe - A Guide for Design and Installation.

4. American Welding Society (AWS):
 - a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
 - b. A3.0M/A3.0, Standard Welding Terms and Definitions Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying.
 - c. D1.1/D1.1M, Structural Welding Code - Steel.
 - d. QC 1, Standard for AWS Certification of Welding Inspectors.
5. ASTM International (ASTM):
 - a. A20/A20M, Standard Specification for General Requirements for Steel Plates for Pressure Vessels.
 - b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
 - c. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
 - d. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
 - e. A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
 - f. A435/A435M, Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates.
 - g. A516/A516M, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
 - h. A770/A770M, Standard Specification for Through-Thickness Tension Testing of Steel Plates for Special Applications.
 - i. A1018/A1018M, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Hot-Rolled, Carbon, Commercial, Drawing, Structural, High-

Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

j. E329, Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.

k. E1255, Standard Practice for Radioscopy.

6. International Organization for Standardization (ISO): 9001:2000, Quality Management Systems - Requirements.

7. Lloyd's Registry.

8. Steel Pipe Fabricators Association (SFPA).

1.02. DEFINITIONS

A. Fittings: Including, but not limited to fittings, closure pieces, bends, reducers, tees, wyes, bifurcations, crosses, outlets, manifolds, nozzles, wall sleeves, bulkheads, and other piping and appurtenances fabricated from steel plate, sheet, or coils as required to provide the Work, complete. Fittings shall include piping above ground or inside structures.

B. Acronyms:

1. CJP: Complete Joint Penetration.
2. CWI: Certified Welding Inspector.
3. MT: Magnetic Particle Testing.
4. NDE: Nondestructive Examination.
5. NDT: Nondestructive Testing.
6. PJP: Partial Joint Penetration.
7. PQR: Procedure Qualification Record.
8. PT: Liquid Penetrant Testing.
9. RT: Radiographic Testing.

10. UT: Ultrasonic Testing.
11. VT: Visual Testing.
12. WPQ: Welder/Welding Operator Performance Qualification.
13. WPS: Welding Procedure Specification.

1.03. DESIGN REQUIREMENTS

A. Fittings:

1. Design reinforcement, unless otherwise shown.
2. Design in accordance with AWWA M11, AWWA C200, and AWWA C208 as modified herein, and this specification.

B. Pipe Layout:

1. Design in accordance with AWWA M11:
 - a. General:
 - (1) Base stationing and elevation convention as indicated on the Drawings.
 - (2) Maximum Laying Lengths:
 - (a) Not limited, unless specifically indicated on the Drawings.
 - (b) Select lengths to accommodate installation operation.
 - b. Include, as minimum:
 - (1) Specific number, location, and direction of each pipe, joint, and fitting. Number each pipe in installation sequence.
 - (2) Station and centerline elevation at changes in grade or horizontal alignment.
 - (3) Station and centerline elevation to which bell end of each pipe will be laid.

- (4) Elements of curves and bends, both in horizontal and vertical alignment.
- (5) Location of mitered pipe sections, beveled ends for alignment conformance, butt straps, and deep bell lap joints for temperature stress control.
- (6) Location of closures, cutoff sections for length adjustment, temporary access manways, vents, and weld lead outlets for construction convenience.
 - (a) Provide for adjustment in pipe laying headings and to conform to indicated stationing.
 - (b) Changes in location or number will require Engineer approval.
- (7) Location of bulkheads, both those shown and as required, for hydrostatic testing of pipeline.

C. Welding Procedure Specification (WPS):

- 1. Qualified by testing in accordance with ASME BPVC SEC IX for shop welds and AWS D1.1/D1.1M for field welds.
- 2. PQRs conducted on unlisted base metal (most coil products are unlisted base metals) to be production welded as required in the referenced welding Code shall be traceable to heat lots.
- 3. Written WPS required for welds, both shop and field.
- 4. Notch-tough welding procedures that require heat input control shall be required:
 - a. AWS D1.1/D1.1M prequalified welding procedures are not allowed.
 - b. WPS used to shop fabricate pipe shall be qualified in accordance with ASME BPVC SEC IX and shall include Supplementary Essential Variables.
 - c. WPS used to field install pipe shall be qualified for heat input control in accordance with AWS D1.1/D1.1M.

- d. PQRs shall be qualified for notch tough welding with consideration for thickness of steel, test temperature, and Charpy V-notch CVN values. Refer to AWS D1.1/D1.1M, Table 4.6 PQR Supplementary Essential Variable Changes for CVN Testing Applications Requiring WPS Requalification for SMAW, SAW, GMAW, FCAW, and GTAW and Section 4, Part D Requirements for CVN Testing, Option A (three specimens). CVN test temperature and acceptance shall be same as pipe base metal specified herein.
- D. Pipe Stulling (Interior Bracing): Design for pipe and fittings such that over-deflection and damage is avoided during handling, storage, and installation, including backfill and compaction.

1.04. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Action Submittals:
 - 1. Shop Drawings showing pipe layout.
 - 2. Material list and steel reinforcement schedules for materials specified.
 - 3. Fabrication Information:
 - a. Pipe and fitting details for temporary and permanent facilities that provide:
 - (1) Cylinder thickness.
 - (2) Manufacturing tolerances.
 - (3) Maximum angular deflection limitations of field joints.
 - (4) Closure sections and cutoffs for field length adjustment.
 - (5) Bulkheads, including details for removal of test bulkheads and repair of lining.
 - (6) Crotch plates, wrappers, and/or collars on outlets.
 - (7) Weld lead outlets and plugs.
 - (8) Stulling size, spacing, and layout.

- b. Joint details including:
 - (1) Butt joints.
 - (2) Miter-cut ends for alignment conformance.
 - (3) Lap joints.
 - (4) Special thermal control joints required for control of temperature stresses.
 - (5) Butt strap joints.
 - (6) Flanged joints.
- 4. Welding Data (Shop and Field Welding):
 - a. Show on a weld map, complete information regarding base metal specification designation location, type, size, and extent of welds with reference called out for WPS and NDE numbers in tail of welding symbol.
 - b. Distinguish between shop and field welds.
 - c. Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for all welds.
 - d. Welding and NDE symbols shall be in accordance with AWS A2.4.
 - e. Welding terms and definitions shall be in accordance with AWS A3.0M/A3.0.
 - f. Submit welding data together with Shop Drawings as a complete package.
- 5. Product data for the following:
 - a. Welded Steel Pipe and Fittings:
 - (1) Mill certificates, including chemical and physical test reports showing data consistent with specified requirements for each heat of steel proposed for use.
 - (2) Provide within one week of receiving coil.

b. Flanged Joints

- (1) For each flanged connection, provide reference standard, flange class, dimensional data and bolt hole number, diameter, and pattern.

C. Informational Submittals:

1. Certificates:

- a. Manufacturer's Certificate of Compliance that furnished products meet the requirements of this Specification.

2. Pipe Manufacturer's written Quality Assurance/Control Plan.

3. Statements of Qualification:

- a. Pipe manufacturer.
- b. Fittings fabricator.
- c. Contractor's Shop Inspector.
- d. Contractor's Field Inspector.
- e. NDT Quality Control Personnel.

4. Procedures:

- a. Shop and field welding information; at a minimum include complete welding code paper trail with linkage to Shop Drawings.
- b. Welder Qualifications and Welding Procedure Specifications as specified below:
 - (1) Provide complete joint dimensions and details showing bevels, groove angles, root face, and root openings for all welds.
 - (2) Notch-tough welding procedures required. For shop welding, address supplementary essential variables in addition to essential variables as indicated in ASME Section IX, QW-251.2. For field welding, heat-input, control PQR essential variables as indicated in AWS D1.1/D1.1M, Table 4.6 shall be included. For shop and field welding, provide heat-input table on WPSs for welder guidance.

- (3) PQRs for notch-tough welding shall document heat- input control by monitoring volts, amps, and travel speed or time-rate of change of weld metal volume as calculated by measuring change in electrode length over a period of time. Charpy V-notch tests shall be conducted on weld metal and heat affected zone. Test coupons shall be oriented transverse to final direction of rolling. Full size Charpy specimen test acceptance shall be same as base metal specified herein.
- (4) Written NDT procedures.
- (5) Written description of proposed sequencing of events or special techniques such as:
 - (a) Controlling pipe wall temperature stress during installation.
 - (b) Minimizing distortion of steel.
 - (c) Shop-Applied Cement-Mortar Lining: Include description of machine to be used and list of similar projects where machine was used. Identify pipe size and total footage.
 - (d) Monitoring pipeline temperatures during installation.
 - (e) Written weld repair procedures for the Work.
 - (f) Field coating application and repair.
 - (g) Field lining application and repair.

5. Reports:

- a. Source Quality Control Test Reports:
 - (1) Nondestructive weld testing.
 - (2) Steel impact testing using Charpy V-notch method.
 - (3) Letter from independent testing agency certifying pipe furnished meets requirements of this specification.
- b. Field Quality Control Test Reports:

- (1) Weld tests, including re-examination of repaired welds, on each weld joint for the following tests, as applicable:
 - (a) RT.
 - (b) UT.
 - c. Cement-mortar lining compressive strength tests in accordance with AWWA C205.
- 6. Field Testing Plan: Submit at least 15 days prior to testing and include following information at a minimum:
 - a. Testing dates.
 - b. Piping system and sections to be tested.
 - c. Method of isolation.
 - d. Method of conveying water from source to system being tested.
 - e. Calculation of maximum allowable leakage for piping sections to be tested.
 - f. Plan for discharging water.
- 7. Design calculations sealed by a Registered Professional Engineer licensed in Colorado pipe thickness for design pressure, external loads, buckling, and handling and fittings, including outlet reinforcement details for collars, wrappers, crotch plates, and increased cylinder thickness.
- 8. Temperature Stress Control Plan: Submit at least 45 days prior to installing pipe and include at least the following information:
 - a. Step by step installation procedures and sequencing to demonstrate compliance with temperature control requirements, including:
 - (1) Pipe installation.
 - (2) Joint welding of standard joints and temperature control joints.
 - (3) Pipe bedding and backfill.
 - b. Methods to ensure compliance with procedures by installation personnel.

- c. Equipment to be used to monitor pipe wall temperature.
 - d. Time of day, climatic, or seasonal installation limits to be used to achieve compliance with temperature control requirements.
9. Pipe manufacturer's certification of training of Contractor's pipe installation crews.
10. Pipe manufacturer's field repair procedures for coatings and linings.

1.05. QUALITY ASSURANCE

A. Qualifications:

1. Pipe Manufacturer:

- a. Experienced in fabricating pipe of similar diameters, lengths, and wall thickness required for the Work.
- b. Steel Pipe Fabricators Association (SPFA), Lloyd's Registry Certification, or ISO 9001:2000 Certification.
- c. Demonstrate current production capability for volume of work required for Project.
- d. Experience shall include successful fabrication to AWWA C200 standards of at least 25,000 linear feet of
- e. 36-inch diameter or larger pipe, with wall thickness of 0.2 inches or greater, within past 5-year period.
- f. Experience shall be applicable to fabrication plant facilities and personnel, not company or corporation that currently owns fabrication facility or employs personnel.

2. Fittings Fabricator:

- a. Experienced in fabricating fittings of similar diameters and wall thickness required for the Work.
- b. Steel Pipe Fabricators Association (SPFA), Lloyd's Registry Certification, or ISO 9001:2000 Certification.

- c. Demonstrate current production capability for volume of work required for this Project.
 - d. Experience shall include successful fabrication to AWWA C200 and AWWA C208 standards of at least 25 fittings of 36-inch or larger pipe, with wall thickness 0.2 inch or greater, within past 5-year period.
 - 3. Welders and Welding Operators:
 - a. Shop Welders: In accordance with ASME BPVC SEC IX.
 - b. Field Welders: In accordance with AWS D1.1/D1.1M.
 - 4. Contractor's Inspector for Shop and Field Welding:
 - a. In accordance with AWS QC 1, with knowledge of welding code for the Work.
 - b. After receiving CWI qualification, at least one Shop CWI and one Field CWI shall have 5 years' minimum professional experience related to welding inspection similar to the Work. Other CWIs may work under the supervision of 5-year CWI, provided they have 1 year of related professional experience after receiving CWI qualification.
 - 5. NDT Quality Control Personnel:
 - a. In accordance with requirements of ASNT SNT-TC-1A, NDT Level II.
 - b. After receiving NDT qualification, at least one NDT person shall have 5 years minimum professional experience related to NDT inspection similar to the Work. Other NDT personnel may work under the supervision of 5-year NDT, provided they have 1 year of related professional experience after receiving NDT qualification.
- B. Contractor's Shop Inspector:
 - 1. In accordance with AWWA C200.
 - 2. Responsibilities:
 - a. Verify conformance to use of specified materials and their proper storage.

- b. Monitor conformance to approved WPS.
- c. Monitor conformance to approved NDT procedure specifications.
- d. Monitor conformance of WPQ.
- e. Provide 100 percent visual inspection before, during, and after shop welding.
- f. Coordinate NDT work and review test results.
- g. Maintain records and prepare report confirming results of inspection and testing.

C. Contractor's Field Inspector:

- 1. In accordance with AWWA C206 and AWS D1.1/D1.1M.
- 2. Responsibilities:
 - a. Verify conformance to use of specified materials and their proper storage.
 - b. Monitor conformance to approved WPS.
 - c. Monitor conformance to approved NDT procedure specifications.
 - d. Monitor conformance of WPQ.
 - e. Provide 100 percent VT before, during, and after field welding.
 - f. Coordinate NDT work and review test results.
 - g. Maintain records and prepare report confirming results of inspection and testing.

D. Prefabrication Meeting:

- 1. Hold prior to fabrication of pipe and fittings between representatives of Thornton, Construction Manager, Contractor, Engineer, and pipe fabricator to review following:
 - a. Project scope.

- b. Submittal requirements.
 - c. Testing.
 - d. Inspection responsibilities.
 - e. Shop welding requirements.
 - f. Field welding requirements.
 - g. Shop and field coating and lining requirements.
 - h. Production and delivery schedule.
 - i. Other issues pertinent to the Work.
- E. Inspection of Coating and Lining Application: Qualified manufacturer's technical representative shall visit pipe coating and lining shop and Site at beginning of application process to verify proper workmanship associated with coating and lining application and as may be required to resolve shop or field problems. Submit written report of visit to Engineer.

1.06. DELIVERY, HANDLING, AND STORAGE

A. Pipe Marking:

1. Legibly mark installation sequence number on pipe and fittings in accordance with piping layout. Standard pipe sections do not need sequence number labeled provided wall thickness is clearly marked.
2. Fittings shall be marked at each end with notation "TOP FIELD CENTERLINE".
3. The word "TOP" shall be painted or marked on outside top spigot of each fitting.
4. Mark "TOP MATCH POINT" for compound bends per AWWA C208 so end rotations can be easily oriented in field.

B. Delivery:

1. Securely bulkhead or otherwise seal ends of pipe and fittings prior to loading at manufacturing site.
2. Pipe ends shall remain sealed until installation.

3. Damage to pipe and fittings, including linings and coatings, found upon delivery to Site shall be repaired to Engineer's satisfaction or removed from Site and replaced.

C. Storage:

1. Support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.
2. Support on sand or earth berms free of rock exceeding 3 inches in diameter.

D. Acceptance at Site: Contractor shall inspect all deliveries for acceptance of material on site.

1.07. SEQUENCING AND SCHEDULING

A. Notify Engineer in writing of the following:

1. Pipe Manufacturing: Not less than 14 days prior to starting.
2. Not less than 5 days prior to start of each of the following:
 - a. Welding.
 - b. Coating application.
 - c. Lining application.
 - d. Shop hydrostatic testing.

PART 2 - PRODUCTS

2.01. GENERAL

A. Pipe Manufacturer:

1. Manufacturers: The following or equal.
 - a. Northwest Pipe
 - b. American Spiral Weld Pipe Co. LLC
 - c. Thompson Pipe Group

- d. Mid America Pipe
- 2. Pipe and fabricated fittings shall be responsibility of one main Supplier.
 - 3. If pipe and fabricated fittings are manufactured by separate Suppliers, one main Supplier shall be responsible for formally managing other Supplier. The one main Supplier is responsible for coordination and management of production of all pipe and fittings work of both Suppliers, including, but not limited to:
 - a. Qualifications.
 - b. Submittals.
 - c. Dimensional consistency between pipe and fittings.
 - d. Fabrication.
 - e. Quality assurance.
 - f. Quality control.
 - g. Reporting.
 - h. Shop lining.
 - i. Shop coating.
 - j. Shop testing.
 - k. Field services.
 - l. Delivery schedule.
 - m. Warranties or guarantees.

B. Pipe Size:

- 1. Unless shown otherwise for pipe over 30 inches in diameter, diameter shown shall be considered finished inside diameter after lining.
- 2. For pipe 30 inches in diameter and less, diameter shown shall be per ASME B36.10M.

C. Wall Thickness:

1. Refer to ASME B36.10M for definitions of wall thickness for standard weight pipe and nominal pipe size (NPS).
2. Reinforce to withstand either internal pressures, both circumferential and longitudinal, or external loading conditions, whichever is greater.
3. For internal pressures, see Contract Drawings.
4. For external loading:
 - (1) HS-20 live loads.
 - (2) Deflection Lag Factor of 1.0.
 - (3) Compaction level of 90%.
 - (4) Soil Stiffness Category of SC1.
 - (5) E' based on AWWA M11, Table 5-3.
 - (6) Maximum Depth of Cover of 32 feet at Sta 76+50 with groundwater level 18' above top of pipe.
 - (7) Minimum Depth of Cover of 4.5 feet at Sta 214+00 with groundwater below pipe.
 - (8) Unit Weight of Soil of 130 pcf, saturated condition.
 - (9) 3% maximum deflection.
5. Minimum Plate Thickness: The greater of adjacent mainline pipe, thickness shown, thickness calculated as hereinafter specified, or as shown in Table 1.

Table 1		
Nominal Pipe Diameter (inches)	Pipe Manifolds Piping Above Ground Piping in Structures	Bends Reducers
24 and Under	Standard Weight	Standard Weight
Over 24	Adjacent Pipe Thickness	Adjacent Pipe Thickness

- D. Steel pipe and fittings shall be manufactured, tested, inspected, and marked to comply with AWWA C200 and additional requirements of these Contract Documents.

2.02. FABRICATION

- A. Shop fabricate steel piping fittings and specials in units as long as practicable for safe hauling and installation.
1. No field fabrication will be allowed, unless approved by Engineer.
 2. Do not exceed 50 feet for pipe lengths.
- B. Fabricate fittings and specials to uniform lengths with proper end clearance for the specified types of joint or attachment.
- C. Flanges.
1. Do not weld flanges to nozzles until the nozzles and reinforcements are completely welded to the header.
 2. Accurately space and align flanges so that when connections have been made there will be no stress on the header, piping, or equipment.
- D. Identification marks: Stenciled or otherwise shown at the top of the piping items exterior, and include the following information:
1. As specified in Section 01 61 00 – Common Products Requirements.
 2. Date of manufacture of the item.
 3. Name or trademark of the manufacturer.
 4. Internal diameter in inches.

5. Number of the item, sequential from initial to end station.

2.03. PIPE BARREL

- A. Steel: Provide steel coils for spiral welded steel pipe or steel plate for straight seam welded steel pipe per AWWA C200 and as follows:

1. Specified Minimum Yield Strength: 42,000 psi.
2. Specified Minimum Tensile Strength: 60,000 psi.
3. Minimum Elongation in 2-inch Gauge Length: 21 percent.
4. Steel Quality as follows:

- a. Coils:

- (1) Continuous cast process, fully-killed, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A1018/A1018M, SS Grade 36, Type 1.
- (2) Continuous cast process, fully-killed, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A1018/A1018M, HSLAS Grade 50, Class 2 (modified). Measured yield strength shall not exceed 85 percent of measured tensile strength.

- b. Plate:

- (1) Fully-killed, conforming to ASTM A20/A20M, fine grained practice conforming to physical, manufacturing and testing requirements of ASTM A516/A516M, Grade 70.
- (2) Steel Chemistry: Conform to ASTM A516/A516M, Grade 70. Steel plates that are 3/4-inch thick or greater shall be normalized.

- c. Toughness:

- (1) Charpy V-notch Acceptance Criteria: Transverse specimen orientation, full size specimens, 25 foot-pounds energy at test temperature of 30 degrees F.

(2) Frequency: See Paragraph Steel Toughness Testing for Thickness Equal to or Greater than 7/16 Inches.

5. Minimum nominal wall thickness as indicated on the Drawings. Maximum allowable thickness variation for plate, sheet, or coil shall be 0.010 inch less than ordered thickness.

2.04. FITTINGS

A. Fabrication:

1. Shop fabricate. No field fabrication will be allowed, unless approved by Engineer.
2. Fabricate from materials or straight pipe in conformance with specified requirements and dimensions of AWWA C208, unless otherwise indicated.

B. Crotch Plate: Fabricate from fully-killed, fine grain, pressure vessel steel conforming to ASTM A516/A516M, Grade 70, and as follows:

1. Plates shall be normalized.
2. Perform through-thickness tension testing of plates in accordance with ASTM A770/A770M.
3. Charpy V-notch tests in direction transverse to final rolling shall be performed per ASTM A370 on full size specimens of coupons taken from each plate. Acceptance shall be 25 foot-pounds at 30 degrees F.

C. Bends, Unless Otherwise Indicated:

1. Minimum Radius: 2.5 times pipe diameter or as indicated on the Drawings.
2. Minimum Bend Wall Thickness: Greater of Table 1 above or, if radius is less than 2.5 times pipe diameter, as calculated using equation in Chapter 7 of AWWA M11.
3. Maximum Miter Angle: 11-1/4 degrees on each section resulting in a maximum deflection angle of 22.5 degrees per miter weld as recommended in AWWA C208.
4. Bevels: Vary bevels on miters to provide a constant weld groove angle. For 11-1/4-degree miter, (22.5-degree miter weld) bevels must vary from 18.75 degrees

on OD of bend to 41.25 degrees on ID of bend to provide a constant 60-degree groove angle for CJP welding.

5. Complete joint penetration (CJP) welds on miter welds.

D. Outlets:

1. 24 Inches and Smaller: Fabricate from ASTM A53/A53M, Type E or S, Grade B, standard weight steel pipe.
2. Larger than 24 Inches: Fabricate from ASTM A106/A106M, Grade B, standard weight pipe.
3. Fabricate collar or wrapper reinforcement using same steel as specified for main pipe barrel.

E. Steel Butt-Weld Fittings:

1. 24 Inches and Smaller: In accordance with ASME B16.9 conforming to ASTM A234/A234M.
2. Standard weight.
3. Taper pipe wall at welds at 4:1 for connection to pipe of different wall thickness.
4. Coordinate difference in diameter convention between fittings and AWWA C200 and AWWA C208 pipe and fittings to provide complete piping system as shown.

2.05. JOINTS

A. Shop Welded:

1. Fabricate in accordance with AWWA C200 as modified herein.
2. Complete joint penetration (CJP) butt joints shall be used for longitudinal, girth, and spiral welds, unless otherwise indicated.
3. Lengths of pipe shall not be shop-joined using lap joints.

B. Preparation of Joints for Field Welding:

1. Butt Joint Welded:

- a. Plain ends beveled as required by AWWA C200 and Contractor's field WPS.
 - b. Provide protection for factory beveled pipe ends so ends are not damaged during transport.
 - 2. Lap Joint Welded:
 - a. Single fillet lap joints in preparation for field welding shall be in accordance with AWWA C200.
 - b. Double welded lap joints and butt-strap joints shall be tapped and drilled for testing in accordance with AWWA C206.
- C. Miter-End Cuts:
- 1. Lap Joints:
 - a. As indicated on the Drawings.
 - b. Moderate deflections and long radius curves may be made using miter-end cuts.
 - c. Use only with lap welded joints, unless specifically approved in writing by Engineer.
 - d. Maximum Total Allowable Angle: 5 degrees per pipe joint.
 - e. Provide miter-cut that is cold expanded square with face of miter- cut on bell ends only.
 - f. Mitering of spigot ends will not be permitted.
 - 2. Welded Butt Joints:
 - a. Maximum Total Allowable Angle: 2.5 degrees per pipe joint.
 - b. Minimum Pipe Wall Thickness: 3/8 inch.
 - c. Welded Butt joints shall be CJP.
- D. Special Temperature Control Joint:

1. Temperature control joints will not be required for pipe installed using weld after backfill.
2. Provide a special longer bell end (Special Temperature Control Joint) at a maximum spacing as indicated herein to account for movement on installed pipe as a result of temperature changes. The longer bell end lap shall be 4-inch minimum or as recommended by the manufacturer.
3. Location:
 - a. At intervals not exceeding 300 feet along welded reaches of the pipeline.
 - b. The first regular lap-welded joint outside each concrete encasement or structure.
 - c. Where special temperature control joints occur in a travelled roadway or other inconvenient location, the location of the joint may be relocated to a more convenient location.

2.06. FLANGES

- A. In accordance with AWWA C207.
- B. Refer to Section 33 11 00 for flange gaskets, bolt, nuts, and washers.

2.07. STULLING (INTERIOR BRACING)

- A. Materials:
 1. Shop-Lined Pipe: Wood stulls and wedges.
 2. Unlined Pipe: Steel or wood.
- B. Install stulling for pipe and fittings in accordance with AWWA M11 and the approved submittal and as soon as practical after pipe is fabricated or, for shop-lined pipe, after lining has been applied.
- C. Install stulling in manner that will not harm lining.

2.08. COATING

- A. General:

1. Notify Engineer at least 3 days prior to application of coating products.
2. Holdback of and coating from field-welded shall be as determined by designer for coating system specified.
3. Unless otherwise indicated, coat exterior surfaces of pipe and fittings passing through structure walls from center of wall or from wall flange to end of underground portion.

B. Shop-Applied:

1. Refer to Section 09 97 20: Polyurethane Protective Coatings and Linings.

2.09. CEMENT-MORTAR LINING

A. General:

1. Notify Engineer at least 3 days prior to application of lining products.
2. Holdback of lining from field-welded joints shall be as follows:
 - a. For lap-welded joints and flex couplings, 8 inches.
 - b. For butt-weld and butt-strap joints, 6 inches.

B. Shop-Applied:

1. Applied centrifugally in conformance with AWWA C205. Thickness shall be in accordance with AWWA C205.
2. Lining machine type that has been used successfully for similar work and approved by Engineer.
3. Maintain pipe in round condition during lining operation and thereafter by suitable bracing or strutting.
4. Provide polyethylene or other suitable bulkhead on ends of pipe and on special openings to prevent drying out of lining. Bulkheads shall be substantial enough to remain intact during shipping and storage until pipe is installed.
5. Pipe shall be left bare where field joints occur.

6. Ends of lining shall be left square and uniform. Feathered or uneven edges will not be permitted.

C. Field-Applied:

1. Materials conforming to AWWA C602.
2. Do not use pozzolanic material in mortar mix.
3. Admixtures shall contain no calcium chloride.
4. Wire mesh conforming to AWWA C205.

2.10. CATHODIC PROTECTION

- A. Provide as shown and as specified in applicable specification.

2.11. SOURCE QUALITY CONTROL

- A. Steel Toughness Testing for Thickness Equal to or Greater than 7/16 Inches:

1. Include three impact specimens; conduct test in direction transverse to final direction of the coil rolling.
2. Coils:
 - a. Conduct Charpy Testing per ASTM A370 on an initial coil of each heat to establish uniformity of steel.
 - b. Take test coupons from an initial coil of each heat at locations of outer and inner wrap of coil.
 - c. For each coil that fails to meet acceptance criteria, conduct Charpy Testing on next two coils in that heat.
 - d. Do not use coils that do not qualify in production of pipe.
3. Plate:
 - a. Conduct Charpy Tests on each plate in accordance with ASTM A20/A20M.
 - b. Conduct on full-size (10 mm by 10 mm) specimens from each plate in accordance with ASTM A20/A20M.

- c. Do not use plates that do not qualify in production of pipe.
- B. Crotch Plate:
 - 1. Perform through-thickness tension testing with acceptance criteria per Article 5 of ASTM A770/A770M on each plate.
 - 2. Conduct straight-beam ultrasonic examination with acceptance criteria per Article 6 of ASTM A435/A435M on each plate.
 - 3. Plates that do not qualify shall not be used.
- C. Shop Hydrostatic Pressure Test: In accordance with AWWA C200 Section 5.2, except as follows:
 - 1. General: Hydrostatically test 100 percent of straight pipe prior to application of lining or coating and prior to fabrication of fittings.
 - 2. Pipe: Maintain test pressure for minimum of 2 minutes.
 - 3. Fittings:
 - a. Except as otherwise specified herein, no additional shop hydrostatic test will be required on fittings fabricated from successfully tested straight pipe.
 - b. Test with crotch plates, regardless of whether or not straight pipe sections used were previously tested.
 - c. Test Pressure: Design Pressure of fitting.
 - d. Maintain test pressure for a length of time as required to perform a visual inspection of welds.
 - e. No leakage is allowed.
- D. Joints, Lap-Welded:
 - 1. Fit test minimum of 5 joints, selected by Engineer, of each pipe size used:
 - a. Join pipe ends with proposed adjacent pipe end.
 - b. Match-mark pipe ends.

- c. Record Actual Annular Space:
 - (1) Maximum space at a point.
 - (2) Minimum space at a point.
 - (3) Space at 90-degree intervals; top, bottom, and spring line on both sides.

E. Shop Nondestructive Testing:

- 1. Welds on straight pipe and fittings: Visually examine 100 percent of welds by Contractor's Shop Inspector to criteria in ASME BPVC SEC VIII, Division 1.
- 2. CJP welds on fittings: Perform radiographic or radioscopy spot examination of welds in accordance with ASME BPVC SEC VIII, Div. 1, Paragraph UW- 52 or perform ultrasonic examination of 100 percent of welds in accordance with either ASME BPVC SEC VIII, Div. 1, paragraph UW-53 or API5L Annex E as outlined in AWWA C200.
- 3. Fillet Welds: 100 percent examine using magnetic particle inspection method in accordance with ASME BPVC SEC VIII, Division 1, Appendix 6.

PART 3 - EXECUTION

3.01. INSTALLATION

A. General:

- 1. Joints and related work for field assembly of fittings shall conform to requirements for straight pipe, unless otherwise shown.
- 2. Inspect pipe and fittings before installation. Clean ends thoroughly, remove foreign matter and dirt from inside.
- 3. Make minor field adjustments by pulling standard joints.
 - a. Maximum Allowable Angle: 75 percent of manufacturer's recommended or angle which results from 3/4-inch pull out from normal joint closure, whichever is less.

- b. Maximum Allowable Gap: 1/8 inch between bell and spigot at weld location.
 - 4. Horizontal deflections or fabricated angles shall fall on alignment, as shown within tolerances below.
 - 5. Vertical deflections shall fall on alignment, and pipe angle point locations shall match those indicated on the Drawings within tolerances below.
 - 6. For field-welded joints, pipe 30 Inches in Diameter and Larger:
 - a. Ensure maximum penetration of spigot end into bell end is achieved through use of shop-welded tabs on inside circumference of bell end or by use of a paint stripe.
 - b. If welded metal tabs are used, remove tabs prior to welding inside of joint.
 - 7. Stulling:
 - a. Maintain stulling in place until pipe is completely backfilled and compacted.
 - b. Reinstall stulls that were temporarily removed to facilitate interior welding prior to backfilling.
 - 8. Pipeline Alignment Tolerances:
 - a. Plan: 3 inches.
 - b. Elevation: 3 inches.
 - 9. Pipe Deflection
 - a. Allowable deflection after completion of bedding, backfilling, and compacting shall be less than 2.75% of pre-installed inside diameter. Pipes with deflection exceeding 2.75%, shall be corrected.
- B. Control of Temperature Stresses:
- 1. In accordance with AWWA C206, approved Temperature Stress Control Plan submittal, and this specification.

2. To control temperature stresses, shade unbackfilled special temperature control joint area of pipe from direct rays of sun by use of properly supported awnings, umbrellas, tarpaulins or other suitable materials until pipe is backfilled at least 1 foot over top of pipe. The special temperature control joint area is defined as the entire length of pipe left exposed. Shading materials shall not rest directly on pipe but shall be supported to allow air circulation around pipe. Shading of special temperature control joints is not required when ambient air temperature is below 50 degrees F.
3. Locate special temperature control joints at 300-foot intervals.
4. Install special temperature control joints as indicated on the Drawings.
5. Design, furnish and install a pipeline temperature monitoring system consisting of thermocouple temperature gauges to monitor temperature of steel pipe wall in trench. Gauges shall be located at top inside surface of pipe at intervals not exceeding 50 feet. Handheld portable temperature sensor devices may be used, provided temperature readings are taken at top of pipe at a frequency and spacing that demonstrates compliance with temperature control requirements.
6. Temperature Control Requirements:
 - a. Prior to and during placement of pipe backfill, pipeline steel temperature shall be at or below 90 degrees F. Monitor specified temperature and control for at least 3 hours after placement of pipe backfill. Provide supplemental cooling as required.
 - b. Place pipe backfill from a single heading starting at one special temperature control joint and proceed toward next special temperature control joint.
 - c. During period of pipe backfill placement, pipeline section that is partially backfilled shall be shaded as indicated above. Temperature of partially backfilled pipe shall not be allowed to exceed 110 degrees F. Provide supplemental cooling as required.
 - d. Prior to welding special temperature control joints, pipeline extending 300 feet each direction from joint shall be maintained at or below 85 degrees F. Additionally, pipeline extending 300 feet each direction from joint shall be backfilled to at least 1 foot over top of pipe. Weld special temperature

control joint at specified temperature of 90 degrees or below. Begin and complete weld during coolest time interval of the 24-hour day. Use pipeline temperature monitoring system data to demonstrate to Engineer coolest interval of the day. After field welding of special temperature control joint, pipe temperature for 150 feet in each direction shall be maintained below 110 degrees F for a minimum of 24 hours after special temperature control joint area has been backfilled to at least 1 foot over top of pipe.

3.02. WELDING

- A. Perform welding only in presence of Contractor's Field Inspector.
- B. Conform to AWS D1.1/D1.1M, AWWA C206, approved welding procedures, and referenced welding codes. In case of conflict AWS D1.1/D1.1M shall govern.
- C. Preheat and Interpass temperature requirements for unlisted base metals shall be determined according to AWS D1.1/D1.1M, Annex XI Guideline on Alternative Methods for Determining Preheat.
- D. Rejectable weld defects shall be repaired or redone, and retested until sound weld metal has been deposited in accordance with appropriate welding codes.

3.03. SHOP-APPLIED COATING REPAIR

- A. Exterior surfaces of steel pipe and fittings shall be inspected upon delivery to Site and just prior to backfilling trench.
- B. Repair of Coating: Field repairs shall be made in accordance with requirements of coating system specified.

3.04. FIELD-WELDED JOINT COATING

- A. As required for coating system specified and as recommended by the steel pipe manufacturer.
- B. Weld After Backfill (WAB) using heat shrink sleeves.
 - 1. Welding from the inside of the pipe after backfilling shall only be used on single welded lap joints.

2. After the sleeve application and prior to welding, the pipe must be completely backfilled to final grade for a minimum distance of 20-feet on each side of the welded joint.
3. Prior to WAB installation, a test trial shall be performed with a test pipe that has the heat shrinkable sleeve applied and has been backfilled and interior welded to mimic Project installation. After completion of the test pipe, excavate joint and test the sleeve to confirm the installation process conforms to the requirements of AWWA C216. A successful installation will be proved by inspection that no burns or wrinkling of the sleeve has occurred, zero holidays determined after Contractor provided holiday test, and the coating has not delaminated. If the test pipe passes the testing, the test pipe can remain in place as installed pipe.
4. To ensure the quality of the WAB installation process, the Construction Manager will select five (5) random joints within the first 3,000 feet of pipe installation and three (3) joints per 5,000 feet of pipe installation as the pipe installation progresses to be excavated by the Contractor after completion of the welding. As part of the quality review, Contractor shall perform a holiday test on the sleeve. The Construction Manager will observe the sleeve and testing. If any defects are discovered, Contractor to replace the sleeves at no cost to the Owner. If defective sleeves are discovered during random testing, the Contractor shall excavate and test all remaining sleeves and replace any defective sleeves at no additional cost to the Owner.
5. The Contractor shall schedule manufacturer field training on sleeve application.

3.05. CEMENT-MORTAR LINING FIELD APPLICATION3%

A. General:

1. Except for requirements specified in this section, lining of steel pipe shall be in accordance with AWWA C602.
2. After joints are welded, tested, and coated, and bedding and backfill have been placed, begin cleaning and lining operation with approval of Engineer.
 - a. Access for cleaning and lining operations shall be at pipe access manholes or pipe ends. No cutting of openings in pipe will be allowed, unless approved in writing by Engineer.

- b. Upon approval by Engineer, openings may be cut into pipe in order to gain entry for placing lining. Repair of openings, welding, repair of coatings, and backfilling shall conform to other portions of these Specifications.

3. Internal Cleaning:

- a. Prior to placing lining, pipe shall be thoroughly cleaned of foreign matter, including water.
- b. Cleaning may be by hand or mechanical method that is approved by Engineer.
- c. Waste materials and water from cleaning operations shall not be passed through sections of existing pipe or pipe that has already been lined.
- d. No pipe shall be lined until inspected and approved by Engineer.

4. Protection of Appurtenances:

- a. Prevent mortar from being thrown into pipe openings in accordance with AWWA C602.
- b. Outlet openings shall be trimmed, smoothed, and beveled.
- c. Damaged or defective areas shall be repaired to satisfaction of Engineer.

3.06. CEMENT-MORTAR LINING JOINT APPLICATION

- A. Cement-Mortar Lining: For pipe with shop-applied cement-mortar lining, place lining at joints in accordance with AWWA C205.

3.07. CATHODIC PROTECTION

- A. Apply to pipe as shown and as specified in applicable specification.

3.08. FIELD QUALITY CONTROL

A. Field Welding:

- 1. All welds, 100 percent inspection, shall be VT inspected by Contractor's Field Inspector and marked to indicate acceptance or rejection.

2. Test butt-strap or double-welded lap joint welds by pressurizing connection between the two fillet welds in accordance with AWWA C206.
 - a. Apply air or other Engineer-approved gas into connection between the two fillet welds.
 - b. Paint welds with soap solution.
 - c. Mark leaks indicated by escaping gas bubbles.
 - d. Close threaded openings with flush pipe plugs or by welding them.
3. CJP Welds:
 - a. Inspect 10 percent of butt joint welds with full circumference RT.
 - b. Inspect 10 percent of other groove welds with UT.
4. Inspect 10 percent of lap joint welds with PT or MT
5. Weld Acceptance:
 - a. If, in the opinion of Engineer, inspections indicate inadequate quality of welds, percentage of welds inspected shall be increased.
 - b. Welds to be inspected, if less than 100 percent rate, shall be selected at random by Construction Manager.
 - c. VT: Perform VT per AWS D1.1/D1.1M Paragraph 6.9, Visual Inspection, Statically Loaded Nontubular Connections.
 - d. UT: Perform UT of CJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.13.1.
 - e. RT: Perform RT of CJP butt joint welds in accordance with AWS D1.1/D1.1M, Paragraph 6.12.1.
 - f. PT or MT:
 - (1) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.10.
 - (2) Acceptance shall be in accordance with VT standards specified above.

- g. Remove in manner that permits proper and complete repair by welding.
 - h. Caulking or peening of defective welds is not permitted.
 - i. Retest unsatisfactory welds.
 - 6. Verification acceptance: Owner may conduct random nondestructive inspections of field-welded joints. Inspections will be of an appropriate type for weld being evaluated. Possible types of inspection include, but are not limited to, RT, UT, PT, and VT. Testing will be performed and evaluated per AWS D1.1/D1.1M. Provide access to the Work to the Owner's Verification Inspector.
 - 7. Contractor shall provide a minimum 14-day advance notice of joint grouting to allow Construction Manager to schedule and conduct quality assurance testing and verification.
 - B. Hydrostatic Testing:
 - 1. See Specification 33 14 00: Pressure Testing of Piping.
- 3.09. MANUFACTURER SERVICES
- A. Manufacturer representatives shall be available at the Site for installation assistance and training of pipe installation crews.
 - 1. Coordinate pipe manufacturer's representative services.
 - 2. Pipe manufacturer's representative shall visit Site and instruct, guide, and provide procedures for pipe handling, laying, and jointing at start of pipe installation by each crew.

END OF SECTION

SECTION 33 11 12

DUCTILE IRON PIPE AND FITTINGS

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section describes materials, testing, and installation ductile iron pipe and fittings as shown on the Drawings.

1.02. MANUFACTURER QUALIFICATIONS

- A. Pipe shall be manufactured, lined, and coated by a single manufacturer.
- B. Manufacturer shall have manufactured the sizes of pipe utilized on this project for a minimum of 10 years.
- C. Approved manufacturers include:
 - 1. American Cast Iron Pipe Company
 - 2. U.S. Pipe
 - 3. McWane Ductile

1.03. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's product information including dimensions, lining, and coating.
- C. Manufacturer's qualifications and list of project using the specified materials: 5 years minimum.
- D. Manufacturer's approved installation instructions for the types of joints being used.

PART 2 - MATERIALS

2.01. PIPE

- 1. Pipe shall be cast ductile (nodular) iron, conforming to AWWA C151. Provide pipe in nominal 18- or 20-foot laying lengths.
- 2. The grade of iron shall be 60-42-10, as described in Section 5.2.2.1.1 of AWWA C151.

2.02. PIPE MARKING

1. Plainly mark each length of straight pipe and each fitting at the bell end to identify the design pressure class, the ductile iron wall thickness, and the date of manufacture. Mark the spigot end of restrained joint pipe to clearly show the required depth of insertion into the bell.

2.03. DESIGN CRITERIA

1. Obtain the following information from the Drawings:
2. Elevation of the top of pipe.
3. Nominal internal diameter (I.D.).

2.04. PIPE WALL THICKNESS

1. Minimum wall thickness for pipe having push-on or mechanical joints, restrained joints, plain ends, or cast flange ends shall be as follows, unless otherwise shown in the Drawings:
2. Pressure Class 350.
3. Minimum wall thickness for pipe having threaded flanges shall be Special Thickness Class 53.

2.05. FITTINGS

1. Fittings shall be rated for 350 psi working pressure and made of ductile iron in accordance with AWWA C153 or C110.
2. Fittings shall have flat-faced connections where flanged connections are required. All other ductile iron fittings shall have mechanical joint connections, unless approved by the Engineer.
3. Material with welded-on bosses or outlets shall have a Charpy notch impact value of minimum 10 foot-pounds under the conditions defined in AWWA C151. Test completed welds by the liquid penetrant method per ASTM E165.

2.06. FLANGES

1. Flanges shall be solid back, Class 125 per AWWA C115 or Class 300 per ASME B16.42. Refer to the Drawings for flange classes of mating equipment. Flanges on pipe shall be either cast or threaded. Material shall be ductile iron. Contractor shall verify that flanges are compatible with steel pipe and valve flange connections. All flanges shall be flat faced (no projections or raised face).

2. Flanged pipe and fittings shall be shop fabricated, not field fabricated. Flanges shall be individually fitted and machine tightened in the shop, then machined flat and perpendicular to the pipe barrel. Flanges shall be backfaced parallel to the face of flange. Prior to assembly of the flange onto the pipe, apply a thread compound to the threads to provide a leak-free connection. There shall be zero leakage through the threads at the hydrostatic test pressure without the use of the gasket.

2.07. PIPE LINING

1. Line pipe interior and fittings with cement-mortar per AWWA C104. Cement for lining material shall conform to ASTM C150, Type II or ASTM C595, Type IL.
2. Alternatively, fittings and blind flanges may be lined and coated with fusion-bonded epoxy per Section 09 97 12.
3. Unless seal coat is provided per AWWA C104, maintain a moist environment inside the lined pipe and fittings by sealing the ends with polyethylene sheet.
4. Loose areas of cement mortar lining are not acceptable. Remove and reconstruct lining in areas where quality is defective, such as sand pockets, voids over sanded areas, blisters, drummy areas, cracked areas, and thin spots. Longitudinal cracks in excess of 1/32-inch in width or where crack extends to metal shall be repaired with epoxy. Repair all cracks larger than 1/16-inch with epoxy. Cement linings shall not be repaired at the job site.

2.08. MECHANICAL, PUSH-ON, AND RESTRAINED JOINT ACCESSORIES

1. Gaskets
 - a. Synthetic or natural rubber in accordance with AWWA C111.
 - b. Gasket lubricant shall be in accordance with Section 33 11 00.
2. Bolts and Nuts, Mechanical Joints
 - a. Cor-Blue, or approved equal.

2.09. FLANGED PIPING AND FITTING ACCESSORIES

1. Gaskets, Bolts, Nuts, and Washers, Refer to Section 33 11 00.

2.10. JOINTS

1. Joints in aboveground or submerged piping or piping located in vaults and structures shall be flanged.

2. Joints in buried piping shall be of the push-on or mechanical-joint type per AWWA C111 except where flanged joints are required to connect to valves, meters, and other equipment.
3. Restrained couplings for field closures shall be Dresser Style 38 or equal with restraint rods. Solid sleeve couplings outfitted with mechanical joint restraint system using follower ring and wedges may also be used for field closures, as approved by the Engineer.

2.11. MECHANICAL JOINT RESTRAIN SYSTEM

1. Provide pipe with restrained joints.
2. The mechanical joint restraint system shall use follower rings and wedges.
3. The restraining mechanism shall consist of a follower gland having a seal gasket and individually actuated wedges that increase their resistance to pullout as pressure or external forces increase.
4. The system manufacturer shall provide all the components (follower ring, wedges, and gaskets) for the restraining device.
5. The device shall be capable of full mechanical joint deflection during assembly, and the flexibility of the joint shall be maintained after burial.
6. The joint restraint ring and its wedging components shall be constructed of ductile iron conforming to ASTM A536, Grade 60-42-10.
7. The wedges shall be ductile iron, heat-treated to a minimum hardness of 370 BHN.
8. Dimensions of the gland shall be such that it can be used with mechanical joint bells conforming to AWWA C111 and AWWA C153.
9. The design shall use torque limiting twist-off nuts to provide actuation of the restraining wedges.
10. The mechanical joint restraint shall be available in the size range of three-through 48-inches.
11. Minimum rated pressure shall be 350 psi.
12. Products: Megalug Series 1100 as manufactured by EBAA Iron, Inc., or equal.

2.12. DUCTILE-IRON PIPE WELDMENTS

1. Welding to ductile iron pipe, such as for bosses and joint restraint, shall be done at the place of manufacture of the pipe. Perform welding by skilled welders who have experience in the method and materials to be used. Welders shall be qualified under the standard qualification procedures of the ASME Boiler and Pressure Vessel Code, Section IX, Welding Qualifications.
2. Welds shall be of uniform composition, neat, smooth, full strength, and ductile. Completely grind out porosity and cracks, trapped welding flux, and other defects in the welds in such a manner that will permit proper and complete repair by welding.
3. Completed welds shall be inspected at the place of manufacture by the liquid penetrant method. Conform to the requirements specified in ASTM E165, Method A, Type I or Type II. The materials used shall be water washable and nonflammable.

2.13. MECHANICAL JOINT CONNECTORS

1. Mechanical joint connectors shall be manufactured in accordance with ANSI / AWWA C153 / A21.53 and ANSI / AWWA C110 / A21.10 from high-strength ductile iron in accordance with ASTM Grade 65-45-12.
2. Connectors shall have pressure ratings of 350 psi.
3. Connectors shall be fusion bonded epoxy coated per Section 09 97 12.
4. Connector gaskets shall be SBR in accordance with ANSI/AWWA C111/A21.11.
5. Connector bolts per Section 33 11 00.
6. Connectors shall be Foster Adaptor or approved equal.

PART 3 - EXECUTION

3.01. DELIVERY, UNLOADING, AND STORAGE AT PROJECT SITE

- A. Use unloading and installation procedures that avoid damaging the pipe.
- B. Do not move pipe by inserting any devices or pieces of equipment into the pipe barrel. Field repair linings damaged by unloading or installation procedures.

3.02. SANITATION OF PIPE INTERIOR

- A. During installation operations, do not place tools, clothing, or other materials in the pipe.
- B. When pipe installation is not in progress, close the ends of the installed pipe by a child- and vermin-proof plug.

3.03. INSTALLING FLANGED PIPE AND FITTINGS

- A. Install in accordance with Section 33 11 00.

3.04. INSTALLING BURIED PIPING

- A. Install in accordance with AWWA C600, Section 31 23 43, and as follows:
 - 1. Installation tolerances are one-inch on grade and one-inch on line. Measure for grade at the invert.
 - 2. Assemble restrained joints per manufacturer instructions.
 - 3. Provide thrust blocks where indicated on the Drawings.
 - 4. Bond buried joints as described in Section 26 42 13 and as detailed on the drawings.

3.05. INSTALLING ABOVEGROUND OR EXPOSED PIPING

- A. Install pipe without springing, forcing, or stressing the pipe or any adjacent connecting valves or equipment.

3.06. PAINTING AND COATING

- A. For pipe and fittings located above ground and in vaults/structures, coat per Section 09 97 12.
- B. Provide asphaltic coating on buried pipe per AWWA C151.
- C. Coat buried flanges and buried mechanical and restrained joint bolts, nuts, and glands per Section 09 90 00, System No. 24.

3.07. POLYETHYLENE ENCASEMENT OF BURIED PIPE AND FITTINGS

- A. Wrap buried pipe, fittings, and joints with polyethylene encasement, per Section 09 97 06.

3.08. PIPE CLEANING

- A. Sweep pipe clean of all dirt and debris. If hardened mud exists in the pipe, remove with the use of pressurized water hoses.

3.09. HYDROSTATIC FIELD TESTING

- A. Test in accordance with Section 33 14 00.

3.10. WARNING TAPE

- A. Provide detectable warning tape per Section 33 05 26.

END OF SECTION

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SECTION 33 12 16

VALVES FOR WATER WORKS

PART 1 - GENERAL

1.01. DESCRIPTION

A. This section includes materials, testing, and installation of Contractor-furnished:

1. Gate Valves.
2. Four (4) Function Combination Air Valves.
3. Debris caps.
4. Extension Stems.
5. Valve Box and Position Indicator.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's catalog data and detail construction sheets showing all valve parts. Describe each part by material of construction, specification (such as AISI, ASTM, SAE, or CDA), and grade or type.
- C. Show valve dimensions including laying lengths. Show port sizes. Show dimensions and orientation of valve actuators, as installed on the valves. Show location of internal stops for gear actuators. State differential pressure and fluid velocity used to size actuators. For worm-gear actuators, state the radius of the gear sector in contact with the worm and state the handwheel diameter.
- D. Show valve linings and coatings. Submit manufacturer's catalog data and descriptive literature.
- E. Submittal shall include a list of station locations where each particular type of valve will be installed.
- F. Operation and Maintenance Manuals

PART 2 - MATERIALS

2.01. GENERAL

- A. Install valves complete with operating handwheels, extension stems, gear actuators, and operating nuts required for operation.
- B. Valves shall have the name of the manufacturer and the size of the valve cast or molded onto the valve body or bonnet or shown on a permanently attached plate.
- C. For buried locations, valves shall have mechanical joint ends, unless shown otherwise on the Drawings.

2.02. GATE VALVES

- A. Provide resilient seated valves with non-rising stems conforming to AWWA C509/C515.
- B. Body and Bonnet: ASTM A536 ductile iron.
- C. Wedge: ASTM A536 ductile iron encapsulated with EPDM.
- D. Valves shall be of the bolted-bonnet type with non-rising stems. Valve stems shall be Type 304 or 316 stainless steel or cast, forged, or rolled bronze.
- E. Valves shall be open left.
- F. Provide operating nut for buried valves and handwheel for valves in vaults. Stem nuts shall be made of solid bronze.
- G. Body bolts shall be Type 316 stainless steel.
- H. End connections for buried valves shall be mechanical joint type, unless shown otherwise on the Drawings. For gate valves used to isolate blowoff piping, the valves shall be flange by mechanical joints.
- I. Flanged end shall be flat faced (no projections or raised face).
- J. Provide reduction thrust bearings above the stem collar. Stuffing boxes shall be O-ring seal type with two rings located in stem above thrust collar. Each valve shall have a smooth unobstructed waterway free from any sediment pockets. Valves to be capable of being repacked or O-ring replaceable while under pressure.
- K. Provide all gate valves with all internal and external wetted parts coated with fusion-bonded epoxy in accordance with ANSI/AWWA C550.

- L. Pressure Rating: 350 psi.
- M. Flanged Ends: ASME B16.1 Class 125
- N. Manufacturers:
 - 1. Mueller A-2361
 - 2. Kennedy Valve 8561 (FLXFL), 8572 (FLXMJ)
 - 3. American Flow Control Series 3500

2.03. COMBINATION AIR RELEASE AND VACUUM VALVES

A. Design

- 1. Function: Valves shall have four (4) functions:
 - a. Air exhaust during pipeline filling.
 - b. Allow entry during pipeline draining to mitigate vacuum conditions.
 - c. Release of entrained air that accumulates during operations.
 - d. Slow closure / anti-shock feature during transient conditions.
- 2. Orifice Sizing: The intake/discharge orifice area shall be equal to the nominal size of the valve, i.e., a 4-inch valve shall have 4-inch full flow inlet and 4-inch outlet. Area around the floats must equal equivalent area of inlet/outlet.
- 3. Pressure Rating: Minimum working pressure as indicated on the Drawings, stainless steel body, cover float and trim, built and tested to AWWA C512. Provide with “anti-shock” and “anti-surge” features. Suitable for raw water service.

B. Materials of Construction

- 1. Body: Stainless Steel AISI 304L or 316L.
- 2. Floats: High Density Polyethylene or Ultra High Molecular Weight Polyethylene.
- 3. Flanges: See Drawings for connecting flange class. Supplied valve flange shall be compatible with flange class it is connecting to. Flanges shall be flat faced (no projections or raised face).

C. Manufacturers: One of the following:

1. Cla-Val Model 39A.
2. International Valve, Vent-Tech, Water Valve WTR.

2.04. DEBRIS CAPS FOR BURIED SERVICE

- A. Debris cap shall be comprised of a hollow member having a cylindrical outer surface, a closure for one end, and three resilient contact pads projecting from the outer surface. Stainless steel springs under each contact pad shall hold the debris cap in position against the interior of the extension pipe or valve box. Provide handle to allow the contact pads to be extended and retracted.
- B. The cap shall have a flexible skirt providing an outward seal preventing debris from passing the cap. The cap shall withstand, without slipping, a minimum vertical force of 50 pounds when the contact pads are extended against the wall of the extension pipe or valve box.
- C. The cap shall be made of molded ABS plastic material. The cap shall have retaining prongs to retain a copper locating wire coil. Provide locking mechanism to accept a lock furnished by the Owner.
- D. Manufacturer: SW Services, Phoenix, Arizona, or approved equal.

2.05. EXTENSION STEMS

- A. Where the depth of the valve is such that its centerline is more than four-feet below grade, provide operating extension stems to bring the operating nut to a point six-inches below the surface of the ground and/or box cover.
- B. Extension stems shall be Type 316 stainless steel, solid core, and shall be complete with two-inch-square operating nut. The connections of the extension stems to the operating nuts and to the valves shall withstand without damage a pull of 300 foot-pounds.
- C. Bolts, nuts, screws, and washers shall be Type 316 stainless steel.
- D. Manufacturers: Trumbull Industries, Inc., Adjustable Stem Guide, or approved equal.

2.06. VALVE BOX AND POSITION INDICATOR

- A. Provide buried valves or valves located inside vaults with valve boxes and positions indicators as indicated on the Construction Drawings.

- B. The position indicators shall show valve position and the direction and number of turns required to fully open (or close). All internal gearing shall be sealed.
- C. Position indicators shall be Trumbull, Pratt Diviner, or approved equal.

2.07. BOLTS AND NUTS FOR FLANGED VALVES

- A. Bolts and nuts for flanged valves shall be as described in Section 33 11 00.

2.08. GASKETS FOR FLANGED VALVES

- A. Gaskets for flanged end valves shall be as described in Section 33 11 00.

2.09. PACKING, O-RINGS, AND GASKETS

- A. Unless otherwise stated in the detailed valve specifications, packing, O-rings, and gaskets shall be one of the following non-asbestos materials:
 - 1. Teflon.
 - 2. Kevlar aramid fiber.
 - 3. Acrylic or aramid fiber bound by nitrile. Products: Garlock "Bluegard," Klinger "Klingersil C4400," or approved equal.
 - 4. Buna-N (nitrile).

2.10. PAINTING AND COATING

- A. Line and coat valves with fusion-bonded epoxy per Section 09 97 12 to a minimum DFT of 8 mils.
- B. For valves located above ground or in vaults or structures where field applied coatings are indicated on the Construction Drawings, coat valves per Section 09 90 00, System No. 10. Apply the specified prime coating system at the place of manufacture compatible with an epoxy intermediate and finish coating system. Apply intermediate and finish coating system in the field. Finish coat shall match the color of the adjacent piping. Coat handwheels the same as the valves.
- C. Measure the thickness of the valve interior linings per Section 09 90 00. Repair areas having insufficient film thickness per Section 09 90 00.
- D. Flange faces shall be shop-coated with a rust preventive compound. Manufacturers: Rust-Oleum R-9 or approved equal.

- E. Test the valve interior linings at the factory. All valve exterior coatings shall be tested in the field. Use a low-voltage (22.5 to 80 volts, with approximately 80,000-ohm resistance) holiday detector, using a sponge saturated with a 0.5% sodium chloride solution. The lining shall be holiday free.

PART 3 - EXECUTION

3.01. SHIPMENT

- A. Any valve appurtenances, accessories, parts and assemblies that are shipped unassembled shall be packaged and tagged in a manner that will protect the equipment from damage and facilitate the final assembly in the field.
- B. Care shall be taken in loading, transporting and unloading to protect valves, appurtenances, or coatings from damage. Equipment shall not be dropped. All valves and appurtenances shall be examined before installation and no piece shall be installed which is found to be defective. Any damage(s) shall be repaired.
- C. Prior to shipping, valves and all associated accessories shall be acceptably packaged and covered to prevent entry of foreign material.
- D. All packaged valves shall be shipped, remain covered and stored on site until they are installed and put into use.

3.02. JOINTS

- A. Bolt holes of flanged valves shall straddle the horizontal and vertical centerlines of the pipe run to which the valves are attached. Clean flanges by wire brushing before installing flanged valves. Clean flange bolts and nuts by wire brushing, lubricate threads with oil and graphite, and tighten nuts uniformly and progressively. If flanges leak under pressure testing, loosen or remove the nuts and bolts, reseal or replace the gasket, reinstall or retighten the bolts and nuts, and retest the joints. Joints shall be watertight.
- B. Clean threaded joints by wire brushing or swabbing. Apply Teflon joint compound or Teflon tape to pipe threads before installing threaded valves. Joints shall be watertight.

3.03. VALVE LEAK TESTING

- A. Test valves for leakage at the same time that the connecting pipelines are tested. See Section 33 14 00 for pressure testing requirements. Protect or isolate any parts of valves, actuators, or control and instrumentation systems whose pressure rating is less

than the pressure test. Valves shall show zero leakage. Repair or replace any leaking valves and retest.

- B. Each assembled air valve shall be tested in accordance with AWWA Standards.

3.04. VALVE FIELD TESTING

- A. Operate manual valves through three full cycles of opening and closing. Valves shall operate from full open to full close without sticking or binding. If valves stick or bind, or do not operate from full open to full closed, repair or replace the valve and repeat the tests.

END OF SECTION

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SECTION 33 14 00

PRESSURE TESTING OF PIPING

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section specifies the cleaning and hydrostatic and leakage testing of pressure piping for transmission mains.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit test bulkhead locations and design calculations, pipe attachment details, and methods to prevent excessive pipe wall stresses.
- C. Submit six copies of the test records to the Construction Manager upon completion of the testing.
- D. Submit product information for the positive displacement hydraulic force pump.

1.03. TEST SEGMENTS AND PRESSURES

- A. The pipeline shall be tested in three (3) separate segments so that the pipeline installed within Larimer County Road is tested immediately after installation and backfilling.
- B. The field hydrostatic test reaches and associated hydraulic grade lines shall be as follows.
 - 1. Test Segment No. 1 (West) – Station 10+00 – 124+95, HGL Elevation – 5,777 feet
 - 2. Test Segment No. 2 (Center) – Station 124+95 – 176+52, HGL Elevation – 5,762 feet
 - 3. Test Segment No. 3 (East) – Station 176+52 – 314+27, HGL Elevation – 5,722 feet
- C. Contractor supply and add intermediate test bulkheads (4) and side outlet manways (4) for access and bulkhead removal and final grouting at Stations 124+95 and 176+52. Intermediate bulkheads at this location shall be installed within 10 feet of the stations listed.
- D. After completion of the pipe installation and test bulkheads, the Engineer will work with the Contractor to determine the specific test pressures to be achieved at the location of the test pump(s) and pressure gauges.

1.04. TESTING RECORDS

- A. Provide records of each test segment. These records shall include:
 - 1. Date and times of test.
 - 2. Identification of pipeline section tested or retested.
 - 3. Identification of pipeline material.
 - 4. Identification of pipe specification.
 - 5. Test fluid.
 - 6. Test pressure at ends of the test segment and the segment's low point.
 - 7. Any leaks identified (type and location), types of repairs, or corrections made.
 - 8. Certification by Contractor that the segment had no leakage and conformed to the specifications.

PART 2 - MATERIALS

2.01. VENTS AND DRAINS FOR ABOVEGROUND PIPING

- A. Install vents on the high points of aboveground piping, whether shown in the drawings or not. Install drains on low points of aboveground piping, whether shown in the drawings or not. Provide a valve at each vent or drain point. Valves shall be $\frac{3}{4}$ -inch for piping three-inches and larger and $\frac{1}{2}$ -inch for piping smaller than three-inches. Valves shall be gate valves per Section 33 12 16, unless otherwise shown in the drawings.

2.02. MANUAL AIR-RELEASE VALVES FOR BURIED PIPING

- A. Provide temporary manual air-release valves at test bulkheads for testing. Construct the pipe outlet in the same manner as for a permanent air valve and after use, seal with a blind flange, pipe cap, or plug and coat the same as the adjacent pipe.

2.03. TEST BULKHEADS

- A. Design and fabricate test bulkheads per Section 33 11 11. Install bulkheads as shown on the drawings and as required for testing.
- B. Reference 1.03.C for information on intermediate test bulkheads.

2.04. TESTING WATER

- A. Potable or raw water may be used for hydrostatic testing. Pipeline may be filled by connecting to existing pipelines or water sources and the use of Contractor-supplied auxiliary pumps connected to the new pipeline.
- B. Potential water sources are as follows:
 - 1. East Larimer County Water District - (970) 493-2044.
- C. Submit request for use of water from any water source Owners six (6) months in advance.
- D. The Contractor shall make sure that water used for filling and testing is clean, free of oils and contamination, and the pH neutral (minimum of 7).
- E. Upon discharging of test water, the Contractor shall make necessary water quality adjustments to conform to discharge permit requirements.

2.05. TESTING EQUIPMENT

- A. Provide calibrated pressure gauges, pipes, bulkheads, pumps, chart recorder, and meters to perform the hydrostatic testing.
- B. Provide a positive displacement hydraulic force pump. Pump shall exhibit no leakage throughout the duration of the pressure test. Provide a pump with an adjustable high/low setting that can be preset to maintain a certain range of pressure for a predetermined amount of time.

PART 3 - EXECUTION

3.01. TEST PREPARATION AND COMPLETION

- A. Pipes shall be in place, backfilled, and anchored before commencing pressure testing.
- B. Conduct pressure tests on exposed and aboveground piping after the piping has been installed and attached to the pipe supports, hangers, anchors, expansion joints, valves, and meters.
- C. For buried piping, the pipe may be partially backfilled and the joints left exposed for inspection during an initial leakage test. Perform the final pressure test, however, after completely backfilling and compacting the trench.
- D. Provide temporary piping needed to carry the testing fluid to/from the pipe being tested. After the test has been completed and demonstrated to comply with the specifications, disconnect and remove temporary piping. Do not remove exposed vent

and drain lines at the high and low points in the tested piping; remove any temporary buried valves and cap the associated outlets. Plug taps or connections to the existing piping from which the testing fluid was obtained.

- E. Prior to starting the test, the Contractor shall notify the Construction Manager in writing a minimum of 5 days prior to testing.
- F. Contractor shall assume that the test segments will need to be fully drained after testing.

3.02. CLEANING

- A. Before conducting hydrostatic tests, the pipeline shall be clean. Sediment, dirt, and foreign material accumulated during cleaning operations shall be discharged, vacuumed, or otherwise removed from the pipe.
- B. The following methods of cleaning are acceptable:
 - 1. High-pressure water jet
 - 2. Sweeping
 - 3. Scrubbing

3.03. PIPELINE FILLING VELOCITIES

- A. The maximum rate of filling shall not cause water velocity in the pipeline to exceed one foot-per-second (1 ft/s). Filling may be facilitated by removing automatic air valves and releasing air manually.

3.04. TESTING NEW PIPE THAT CONNECTS TO EXISTING PIPE

- A. Prior to testing new pipelines that will be connected to existing pipelines, isolate the new line from the existing line by means of test bulkheads, spectacle flanges, or blind flanges. After successfully testing the new line, remove test bulkheads or flanges and connect to the existing piping.

3.05. TESTING OF ABOVEGROUND OR EXPOSED PIPING

- A. Open vents at high points of the piping system to purge air while filling the pipe with water. Venting during system filling may also be provided by temporarily loosening flanges.
- B. Subject the piping system to the test pressure indicated. Maintain the test pressure for a minimum of two (2) hours. Examine joints, fittings, valves, and connections for leaks.

The piping system shall show zero leakage or weeping. Correct leaks and retest until zero leakage is obtained.

3.06. TESTING OF BURIED PIPING

- A. Where any section of the piping contains concrete thrust blocks or encasement, do not perform the pressure test until at least ten (10) days after placing the concrete.
- B. Fill the pipe to be tested with water and allow it to soak for a minimum of twenty-four (24) hours to absorb water before conducting the pressure test.
- C. Apply and maintain the test pressure by means of a leak-free positive displacement hydraulic force pump.
- D. Once the test pressure is achieved it must be maintained for a minimum of (2) hours without leakage. The use of any makeup water to maintain test pressure will be cause for a failed test.
- E. Repair and retest any pipes that demonstrate leakage.

3.07. REPETITION OF TEST

- A. If leakage occurs, locate and correct the faulty work and repeat the test. Restore the work and all damage resulting from the leak and its repair.

3.08. TEST COMPLETION

- A. Drain and leave the pipe clean after successful testing.

3.09. TEST WATER DISPOSAL

- A. The Contractor shall drain water from the pipeline after hydrostatic testing in accordance with the CDPHE Hydrostatic Testing Discharge Permit. Some maintenance water may be left in the pipe to provide adequate humidity to prevent the cement mortar lining from cracking.
- B. Water Quality Requirements
 - 1. Contractor shall discharge water in such a manner to ensure no damage to adjacent properties.
 - 2. Contractor shall adjust the water quality as needed by adding chemicals to maintain pH and chlorine levels per the discharge permit requirements.
- C. Maximum rate of draining shall not cause water velocity in pipeline to exceed 1/2 foot-per-second.

3.10. BULKHEAD AND TESTING EQUIPMENT REMOVAL

- A. After successful field testing, carefully drain test water, remove test bulkheads and other test equipment, and restore pipe linings and coatings.

END OF SECTION

SECTION 33 41 02

CORRUGATED STEEL PIPE

PART 1 - GENERAL

1.01. GENERAL

- A. This specification covers the manufacture and installation of galvanized corrugated steel pipe (CSP), flared-end sections, coupling bands with gaskets, and fastening and connecting hardware.

1.02. REFERENCES

- A. American Association of State Highway and Transportation Officials (AASHTO)
 - 1. M218 – Standard Specification for Steel Sheet, Zinc-Coated (Galvanized), for Corrugated Steel Pipe.
 - 2. M36 - Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains.
 - 3. LRFD Bridge Design, latest revision.
 - 4. Standard Specification for Highway Bridges, latest revision.
- B. American Society for Testing and Materials (ASTM)
 - 1. A760 – Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains.
 - 2. A798 – Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications.
 - 3. A929 – Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe.
- C. American Iron and Steel Institute (AISI)

1.03. DESIGN STANDARDS

- A. The CSP shall meet the design parameters of the American Association of State Highway and Transportation Officials (AASHTO) Standard Specification for Highway Bridges, AASHTO LRFD Bridge Design, and/or the American Iron and Steel Institute (AISI).

1.04. SUBMITTALS

- A. Contractor shall submit shop drawings, manufacturer's data sheets, and specifications for all pipe, flared-end sections, coupling bands with gaskets, and fastening hardware. Include exact dimensions of the pipe joint configuration including the permissible tolerances for each pipe size being furnished and the size, type, and locations of gasket materials.
- B. Submit certified test reports that the pipe was manufactured and tested in accordance with the ASTM and AASHTO Standards specified herein.
- C. Submit deflection testing equipment and deflection testing method.

PART 2 - PRODUCTS

2.01. GENERAL

- A. All CSP piping, flared-end sections, coupling bands with gaskets, and assembly hardware shall be from a single manufacturer. Variations in design and dimensions are permitted to allow for manufacturer's standards.

2.02. CORRUGATED STEEL PIPE (CSP)

- A. The CSP shall be galvanized and manufactured in accordance with AASHTO M36 or ASTM A760.
- B. Ends of the CSP shall be rerolled with annular corrugations to accommodate coupling bands and O-ring gaskets.
- C. Pipe Corrugations: 2-2/3" x 1/2"
- D. Pipe Thickness
 - 1. 12" Diameter – 14 Gage

2. 15" Diameter – 14 Gage
3. 18" Diameter – 14 Gage
4. 30" Diameter – 12 Gage

E. Pipe Manufacturer:

1. Contech Hel-Cor Corrugated Steel Pipe.
2. Or approved equal.

2.03. FLARED-END SECTIONS

- A. Flared-end sections for the CSP shall be made of the same base metal and coating as the CSP.
- B. Flared-end section connection to the CSP shall be per the manufacturer's recommendations.
- C. Flared-end sections shall be supplied with a toe plate extension where indicated on the Drawings. Toe plate extension shall be the same base metal and coating as the flared-end section body.
- D. Manufacturer:
 1. Contech.
 2. Or approved equal.

2.04. COUPLING BANDS WITH O-RING GASKETS

- A. Coupling bands for the CSP shall conform to AASHTO M36 and be made of the same base metal and coating as the CSP to a minimum thickness of 18-gage and a minimum band width of 12 inches.
- B. O-ring gaskets shall be neoprene and supplied with the coupling bands.
- C. Coupling bands shall have bar, bolt, and strap connector assemblies.
- D. Manufacturer:
 1. Contech Hugger Band.

2. Or approved equal.

2.05. FASTENERS AND CONNECTING HARDWARE

- A. Fasteners (i.e. bolts, nuts, washers, threaded rods) and connecting hardware shall be in accordance with AASHTO M36. Fasteners and connecting hardware shall be supplied by the pipe manufacturer.
- B. All fasteners and connecting hardware shall be galvanized.

PART 3 - EXECUTION

3.01. GENERAL

- A. The pipe and coating shall be inspected for damage and defects before being placed in the trench. Damaged and defective pipe shall not be installed and be removed and replaced with acceptable materials at the Contractor's expense.

3.02. DELIVERY, STORAGE, AND HANDLING

- A. Shipping: Material shall be shipped so as to not bend, dent, or otherwise damage pipe and accessories during transport.
- B. Pipe and flared-end sections shall not be dropped and stored in such a manner that precludes shock or damage.
- C. Limit stacking of pipe to a height that will cause excessive deformation of bottom layers of pipes.
- D. Where necessary, because of ground conditions, store pipe on wooden sleepers, spaced suitably and of such widths as not to allow deformation of pipe at point of contact with sleeper or between supports.
- E. Pipe shall be handled so as to prevent damage to the pipe ends or to any coating or lining. Pipe shall not be skidded or rolled against adjacent pipe. Damaged coatings or lining shall be repaired in accordance with the recommendations of the manufacturer.
- F. Gasket Storage: All gaskets shall be stored in a cool place, preferably at a temperature of less than seventy degrees Fahrenheit (70°F.), and in no case shall the gaskets be stored in the open, or exposed to the direct rays of the sun.

3.03. INSTALLATION

A. Corrugated Steel Pipe

1. CSP shall be installed in accordance with the manufacturer's recommendations for installing the type of pipe used, unless otherwise shown on the Drawings.
2. CSP shall be laid to the line and grade shown on the Drawings. Variation for the prescribed line and grade shall not exceed one-tenth (0.10) of a foot.
3. Lift or roll pipe to protect the coating. Do not drag over gravel or rocks. Avoid striking rocks or hard objects when lowering into the trench.

B. Flared-End Section

1. Flare-end section shall be laid to the line and grade shown on the Drawings. Variation for the prescribed line and grade shall not exceed one-tenth (0.10) of a foot.
2. Flared-end section connection to the CSP shall be per the manufacturer's recommendations.
3. Where flared-end section toe plate extensions are required on the Drawings, install in accordance with the Construction Details.

C. Coupling Bands with O-Ring Gaskets

1. Join pipe sections with coupling bands and O-ring gaskets in accordance with the manufacturer's recommendations.
2. No gaskets that show signs of deterioration, such as surface cracking, shall be installed in a pipe joint. When the air temperature is ten degrees Fahrenheit (10°F) or lower, the gasket shall be warmed to a temperature of sixty degrees Fahrenheit (60°F) for a period of thirty (30) minutes before being placed on the pipe.

3.04. BEDDING AND BACKFILLING

- A. Bedding and backfilling shall be in accordance with the Drawings and Section 31 23 43.

3.05. FIELD TESTING

A. Alignment

1. Inspect for misaligned, displaced, or broken pipe by flashing a light between openings where space permits.
2. Pipe shall be cleaned of dirt and debris prior to inspecting.

B. Deflection Testing

1. The maximum installed deflection of CSP shall be five percent (5%) of the mean internal diameter.
2. Prior to testing, Contractor shall obtain approval of deflection testing method (i.e. rigid ball, mandrel, etc.) and equipment used to perform testing. Testing shall be performed without mechanical pulling devices.
3. Pipe exceeding the deflection limits, shall be replaced or re-compacted at the Contractor's expense.

3.06. CLEAN-UP

- A. All rubbish, unused materials, excess spoils, and other non-native materials shall be removed and properly disposed of offsite.
- B. Restore surface in accordance with Contract Documents.

END OF SECTION

SECTION 33 82 05
FIBER OPTIC CONDUIT

PART 1 - GENERAL

1.01. DESCRIPTION

- A. This section describes materials and installation of fiber optic conduit, hand holes and accessories.

1.02. SUBMITTALS

- A. Make submittals in accordance with the General Conditions and Section 01 33 00.
- B. Submit manufacturer's data, specifications, and installation instructions for each product type required.
- C. Submit mandrels for the mandrel testing as recommended by the HDPE conduit manufacturer.

PART 2 - MATERIALS

2.01. FIBER OPTIC CONDUIT

- A. Fiber optic conduit shall be Schedule 40 or 80 flexible high-density polyethylene (HDPE) manufactured in accordance with ASTM F2160 and meet UL 651A.
- B. HDPE conduit properties shall meet or exceed the following:
 - 1. Density: 0.941-0.955 g/cm³
 - 2. Flexural Modulus: 80,000 psi
 - 3. Tensile Strength: 3,000 psi
 - 4. Melt Index: 0.05-0.50 g/10 minutes
 - 5. Brittleness Temperature: -75°C
 - 6. UV Stabilizer: Black, minimum 2% carbon
 - 7. Hardness: Shore D 60
- C. HDPE conduit shall have longitudinal ribbed interior with silicone lining and a smooth exterior.

- D. Mechanical fittings and couplings shall be from the same manufacturer as the HDPE conduit.
- E. HDPE conduit shall have preinstalled pull tape with a minimum tensile strength of 2,500 lbs. Pull tape shall be supplied with sufficient slack. Cap ends of conduit to prevent wildlife, rainwater and sediment entry.
- F. Color: Orange (Telecommunications)
- G. Size: Refer to the Construction Drawings.
- H. HDPE conduit shall be ARNCO, Carlon, Dura-Line, JM Eagle, Oxford Plastics, Performance Pipe, or approved equal.

2.02. HAND HOLES

- A. Hand holes shall be made of polymer concrete rated Tier 22 for occasional non-deliberate heavy vehicular traffic.
- B. Hand hole size: See Construction Drawings.
- C. Boltdown hardware: 316 stainless steel.
- D. Cover: standard, non-skid surface marked with "Communication" or "Fiber".
- E. Hand holes shall be Armorcast, Oldcastle, or approved equal.

2.03. BURIED PRECAST MANHOLES

- A. Refer to Section 03 42 10 and the Construction Drawing details.

2.04. THROUGH WALL SEALS AND BUSHINGS

- A. Installation at new walls: Emerson O-Z/Gedney FSK
- B. Installation at existing walls: Emerson O-Z/Gedney CSM

2.05. TRACER WIRE

- A. Refer to Specification Section 33 05 26.

2.06. UNDERGROUND WARNING TAPE

- A. Refer to Specification Section 33 05 26.

2.07. GROUT

- A. Refer to Specification Section 03 30 00.

PART 3 - EXECUTION

3.01. FIBER OPTIC CONDUIT

- A. Install fiber optic conduit per the Construction Drawings.

3.02. HAND HOLES

- A. Install hand holes where indicated on the Construction Drawings.
- B. Make conduit penetrations in the hand hole per the manufacturer's recommendation or pull conduits up from below the box.

3.03. BURIED CONCRETE MANHOLES

- A. Install buried concrete manholes where indicated on the Construction Drawings.

3.04. THROUGH WALL SEALS AND BUSHINGS

- A. Install per the manufacturer's recommendations.

3.05. TRACER WIRE

- A. Refer to Specification Section 33 05 26.

3.06. UNDERGROUND WARNING TAPE

- A. Refer to Specification Section 33 05 26.

3.07. MANDREL TESTING

- A. Mandrel testing shall be performed on HDPE conduits installed within casings or tunnels.
- B. Mandrel testing shall be witnessed by the Construction Manager and backfilling of the tunnel shaft shall not begin until mandrel testing is complete.
- C. Mandrels as recommended by the HDPE conduit manufacturer shall be approved for use prior to the field testing.

END OF SECTION

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